APPENDIX A

DATA TABLES

DATA TABLES

Table 3. Worker Exposure at 1% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-1	120	23.4	0.762	0.179
BC-2	120	23.76	0.670	
				15 Minute STEL (ppm)
BC-6	15	2.97	1.0	0.93
BC-7	15	2.95	0.85	
BC-9	15	2.97	1.1	1.1
BC-10	15	2.95	1.1	
BC-12	15	2.97	0.90	0.87
BC-13	15	2.95	0.84	

Table 4. Helper Exposure at 1% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-3	120	23.04	0.14	0.035
				15 Minute STEL (ppm)
BC-8	15	2.98	0.27	0.27
BC-11	15	2.98	0.24	0.24
BC-14	15	2.98	0.24	0.24

Table 5. Area Samples at 1% Benzene

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)
BC-4	120	23.28	0.11
BC-5	120	23.52	0.10

Table 6. Worker Exposure at 7% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-15	120	23.4	1.51	0.351
BC-16	120	23.76	1.30	
				15 Minute STEL (ppm)
BC-20	16	3.17	5.03	4.87
BC-21	16	3.15	4.70	
BC-23	15	2.97	1.3	1.15
BC-24	15	2.95	1.0	
BC-26	15	2.97	1.3	1.25
BC-27	15	2.95	1.2	

Table 7. Helper Exposure at 7% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-17	120	23.04	0.24	0.060
				15 Minute STEL (ppm)
BC-22	16	3.18	0.92	0.92
BC-25	15	2.98	0.24	0.24
BC-28	15	2.98	0.24	0.24

Table 8. Area Samples at 7% Benzene

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)
BC-18	120	23.28	0.301
BC-19	120	23.52	0.319

Table 9. Worker Exposure at 30% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-29	121	23.56	2.72	0.585
BC-30	121	23.96	1.92	
				15 Minute STEL (ppm)
BC-34	15	2.97	2.36	1.88
BC-35	15	2.95	1.4	
BC-37	15	2.97	2.0	1.95
BC-38	15	2.95	1.9	
BC-40	15	2.97	3.53	3.51
BC-41	15	2.95	3.49	

Table 10. Helper Exposure at 30% Benzene in Liquid Wrench

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)	Calculated 8-hr. TWA (ppm)
BC-31	120	23.04	0.638	0.160
				15 Minute STEL (ppm)
BC-36	15	2.98	0.23	0.23
BC-39	16	3.18	0.51	0.51
BC-42	15	2.98	2.1	2.1

Table 11. Area Samples at 30% Benzene

Sample No.	Sampling Time (min.)	Air Sample Volume (liters)	Benzene in Air Concentration (ppm)
BC-32	63	12.22	0.14
BC-33	63	12.35	0.14

APPENDIX B

Assessment Protocol

Protocol for Assessing Benzene Exposure During Actual and Simulated Mechanical Tasks Utilizing Liquid Wrench

1. Prepare representative Liquid Wrench aliquots for use in this exposure study that contain differing concentrations by weight of benzene to mimic the concentrations of benzene that were allegedly produced in the Liquid Wrench product. EPI will use benzene/Liquid Wrench concentrations (w/w) of 1%, 7% and 30% for this exposure study. The Liquid Wrench/benzene solution will be applied over a 2-hour period in quantities necessary for the removal of the nuts/bolts. Approximately 8 liquid ounces (236 ml) of each weight percentage solution will be made for use during the study.
2. Obtain three typical valve assemblies containing a minimum of three flange assemblies each that include rusted bolts and nuts that must be removed in order to perform work on that valve assembly. One valve assembly containing the three flanges will be used for each concentration of benzene prepared.
3. The test location will be inside a warehouse-type structure that is typical in size of most industrial environments. The workplace environment will be established as static conditions, nominally, no measurable air movement. The complete description of the setting will be documented in the report of findings.
4. The test method used will be the benzene in air sampling and analysis protocol as described in NIOSH 1501. Constant monitoring of the work task resulting in the calculated 8-hr time weighted average (TWA) and repeated 15-minute short-term exposure limit (STEL) samples will be collected and analyzed during each two-hour period. The STEL samples are collected because Liquid Wrench is typically applied only in brief periods of time during the course of a worker's day and during this period of time the concentration of benzene is expected to be at its highest. The worker will have two dual port sampling devices driven by two personal pumps during the sampling phase. One of the ports in each of the dual sampling devices will be used to collect the two-hour samples that will be used for 8-hour TWA calculations. The other port on each of the worker's sampling devices will be used for the collection of three 15-minute STEL samples collected during active use of the Liquid Wrench/benzene solution. The helper will wear one dual port sampling device driven by one personal sampling pump. One of the ports will be used for 2-hour sample collection for 8-hour TWA determination. The other sampling port will be for the collection of three 15-minute STEL samples collected during active use of the Liquid Wrench/benzene solution. A dual port sampler driven by a personal sampling pump will be used for area sample collection. Both ports will be used for the collection of two samples used for area monitoring during the study.
5. Set up and calibrate sampling equipment for background (ambient) air monitoring, personal breathing zone monitoring, and area air sampling. Two

personnel in the test area shall be equipped with a personal sampling pumps and sampling media for sample collection as described in No. 4 above during the work task. Benzene in air samples will be collected using the charcoal tube methodology as referenced in NIOSH 1501.

Direct-read colorimetric tube monitoring may be used in conjunction with NIOSH sampling protocols. The direct-read tubes will provide immediate result readings for benzene during the performed tasks.

6. Perform the simulated tasks. The mechanic will apply Liquid Wrench to the rusted nuts and bolts on the valve assembly, wait for it to take effect (approximately 3 to 10 minutes) including tapping on the parts with a hammer, loosen and then re-tighten the rusted nuts on the bolts. (As appropriate, the Liquid Wrench may be reapplied until the nut and bolt assemblies are loosened.) Once the nuts and bolts have been loosened, the mechanic will wait in the vicinity of valve assembly for at least 2 hours, which is deemed to sufficient to have carried out a typical repair activity (e.g., change packing or gasket). The bolts and the nuts will be re-tightened to conclude the simulated mechanical task. The task will be repeated three times for each concentration of benzene. The exposure assessment will be carried out over a two-hour period for each of the Liquid Wrench/benzene concentration solutions.
7. Provide photographic/video recording devices and media to record the task simulations.
8. Considerations:
    - Ambient (background) benzene sampling will be conducted to determine the background contribution of benzene from the test location.
    - The area air sampling location will be set approximately 5 feet from the work task in the test area to evaluate potential bystander exposures. Also, the sampling media will be placed approximately five feet (5') above the floor surface.

APPENDIX C

Material Safety Data Sheet for Liquid Wrench Part No. L-104

L-1pour

MATERIAL SAFETY DATA SHEET

Radiator Specialty Company

1900 WILKINSON BLVD. CHARLOTTE, NC 28208 (704) 377-6555
POISON INFORMATION & EMERGENCY: 303-623-5716

MATERIAL SAFETY DATA SHEET
May be used to comply with OSHA's Hazard Communication Standard 29 CFR 1910.1200. Standard must be consulted for specific requirements.

US DEPARTMENT OF LABOR
Occupational Safety and Health Administration. (Non-Mandatory Form) Form Approved OMB No. 1218-0072

SECTION I GENERAL INFORMATION

PRODUCT NAME	LIQUID WRENCH® SUPER PENETRANT (POUR)
PART NUMBER	L1 04, 04V, 04N, 08, 16, 32, 34, 40, 49

NOTE: Blank spaces are not permitted. If any item is not applicable or no information is available, the space must be marked to indicate that.

SECTION II HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

COMPONENT	WT%	C.A.S. NO.	TLV (ACGIH------OSHA------)
Aliphatic Petroleum Distillate	89-90	8008-20-6	100 ppm (Air)
Petroleum Mineral Oil	9-11	64742-06-9	5 mg/m3

Warning: This product contains a chemical known to the State of California to cause cancer and birth defects or other reproductive harm.
Comments:

Components not identified are non-hazardous according to 29 CFR 1910.1200

SECTION III PHYSICAL/CHEMICAL CHARACTERISTICS

Specific Gravity (H_2O=1)	0.805	**pH**	Not applicable
Solubility in Water	Insoluble	**Solubility in Solvent**	Petroleum
Flash Point (Method) - F°	132° (TCC)	**% Volatiles By Wt.**	90%
Melting Point - F°	N/A	**Boiling Point - F°**	320°
Vapor Pressure (mmHg)	N/A	**Vapor Density (Air=1)**	N/A
Evaporation Rate (Butyl Acetate=1)	N/A		
Appearance and Odor	Dark liquid with petroleum odor.		

SECTION IV FIRE AND EXPLOSION HAZARD DATA

EXTINGUISHING MEDIA: COMBUSTIBLE!

Water Fog	**Foam** xx	**CO_2** xx	**Dry Chemical** xx

SPECIAL FIRE FIGHTING PROCEDURES. Wear self-contained, positive pressure breathing apparatus and protective clothes.

UNUSUAL FIRE AND EXPLOSION HAZARDS KEEP AWAY FORM IGNITION SOURCES AND OPEN FLAME.

L-1pour

SECTION V REACTIVITY DATA

Stable	xx	Unstable		Corrosive NO	Hazardous Polymerization? Yes	No	xx

Incompatibilities Strong oxidizers

Hazardous Decomposition or Byproducts Fire: normal products of combustion, smoke, carbon dioxide, carbon monoxide and Sulfur Trioxides.

SECTION VI HEALTH HAZARD INFORMATION

Recommended TLV of Product 100 ppm (Air) Aliphatic Petroleum Distillate

EYE CONTACT	Irritant	**SKIN CONTACT**	Irritant. Prolonged exposure can cause dermatitis.
INHALATION	Excessive inhalation can cause dizziness, respiratory and lung irritation.	**INGESTION**	HARMFUL OR FATAL IF SWALLOWED! Can cause gastric disturbances, nausea. Aspiration can lead to lung irritation.
OTHER	N/A		

SECTION VII EMERGENCY AND FIRST AID PROCEDURES

EYE CONTACT Flush with water for 15 minutes thoroughly, while lifting the eyelids. If adverse effects persist, get medical attention immediately.

SKIN CONTACT Wash with soap and water thoroughly. Remove contaminated clothing and launder before reuse.

INHALATION Remove to fresh air. If breathing is difficult, administer oxygen. If breathing has stopped , apply artificial respiration. Get medical attention.

INGESTION DO NOT INDUCE VOMITING! Get medical attention immediately. DO NOT ADMINISTER EPINEPHRINE OR ADRENALINE!

SECTION VIII SPECIAL PROTECTION INFORMATION

	CONSUMER	BULK HANDLING (Prolonged Exposure)
RESPIRATORY PROTECTION	N/A	Use NIOSH approved self-contained respirator.
VENTILATION	Use with adequate ventilation.	General
EYE PROTECTION	N/A	Wear fully protective goggles or face shield.
PROTECTIVE CLOTHING	N/A	Solvent resistant gloves and apron.

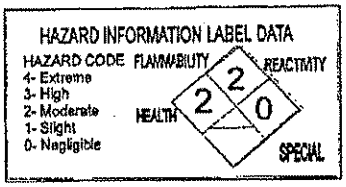
SECTION IX PRECAUTIONS FOR SAFE HANDLING AND USE

SPILL OR LEAK PROCEDURE Observing health hazards described above, ventilate area, remove ignition sources, confine spill, wipe with rags and transfer to waste drum.

WASTE DISPOSAL METHOD ***Dispose of in accordance with all applicable government laws and regulations.***

STORAGE AND HANDLING PRECAUTIONS KEEP AWAY FROM IGNITION SOURCES AND OXIDIZERS!! Store in a cool place.

OTHER PRECAUTIONS WEARING CONTACT LENSES IS INADVISABLE! KEEP AWAY FROM CHILDREN AND ANIMALS!



Supersedes NOV 1998 OSHA Revised OCTOBER 2001

Title R. GEER - CHEMIST

While Radiator Specialty Company believes this data is accurate as of the revision date, we make no warranty with respect to the data and we expressly disclaim all liability for reliance thereon. The data is offered solely for information, investigation, and verification.

APPENDIX D

NIOSH 1501 Sampling & Analytical Method

FORMULA: Table 1 MW: Table 1 CAS: Table 1 RTECS: Table 1

METHOD: 1501, Issue 2 EVALUATION: PARTIAL Issue 1: 15 February 1984
Issue 2: 15 August 1994

OSHA: Table 2
NIOSH: Table 2
ACGIH: Table 2

PROPERTIES: Table 1

COMPOUNDS: benzene; cumene; α-methylstyrene; styrene; vinyltoluene
(Synonyms in Table 1) p-tert-butyltoluene; ethylbenzene; naphthalene; toluene; xylene

SAMPLING

SAMPLER: SOLID SORBENT TUBE (coconut shell charcoal, 100 mg/50 mg)

FLOW RATE, VOLUME: Table 3

SHIPMENT: routine

SAMPLE STABILITY: not determined

BLANKS: 2 to 10 field blanks per set

BULK SAMPLE: desirable, 1 to 10 mL; ship in separate containers from samples

ACCURACY

RANGE STUDIED: Table 3

BIAS: Table 3

OVERALL PRECISION ($\hat{S}_{rT}$): Table 3

ACCURACY: Table 3

MEASUREMENT

TECHNIQUE: GAS CHROMATOGRAPHY, FID

ANALYTE: hydrocarbons listed above

DESORPTION: 1 mL CS_2; stand 30 min

INJECTION VOLUME: 5 µL

TEMPERATURE-INJECTION: 225 °C
-DETECTOR: 225 °C
-COLUMN: see step 11

CARRIER GAS: N_2 or He, 25 mL/min

COLUMN: glass, 3.0 m x 2-mm, 10% OV-275 on 100/120 mesh Chromosorb W-AW or equivalent (Table 4)

CALIBRATION: analytes in CS_2

RANGE AND PRECISION ($\hat{S}_r$): Table 4

ESTIMATED LOD: 0.001 to 0.01 mg per sample with capillary column [1]

APPLICABILITY: This method is for peak, ceiling and TWA determinations of aromatic hydrocarbons. It may be used for simultaneous measurements, though there is the possibility that interactions between analytes may reduce the breakthrough volumes and change desorption efficiencies.

INTERFERENCES: Use of the recommended column will prevent interference by alkanes ($\leq C_{10}$). Under conditions of high humidity, the breakthrough volumes may be reduced by as much as 50%. Other volatile organic solvents, e.g., alcohols, ketones, ethers, and halogenated hydrocarbons, are possible interferences. If interference is suspected, use a less polar column or change column temperature.

OTHER METHODS: This method is based on and supercedes Methods P&CAM 127, benzene, styrene, toluene and xylene [2]; S311, benzene [4]; S22, p-tert-butyltoluene [3]; S23, cumene [3]; S29, ethylbenzene [3]; S26, α-methylstyrene [3]; S292, naphthalene [4]; S30, styrene [3]; S343, toluene [4]; S25, vinyltoluene [3]; S316, xylene [4].

REAGENTS:

1. Eluent: Carbon disulfide*, chromatographic quality containing (optional) suitable internal standard.
2. Analytes, reagent grade.*
3. Nitrogen or helium, purified.
4. Hydrogen, prepurified.
5. Air, filtered.
6. Naphthalene calibration stock solution, 0.40 g/mL in CS_2.

* See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Sampler: glass tube, 7 cm long, 6-mm OD, 4-mm ID, flame-sealed ends, containing two sections of activated (600 °C) coconut shell charcoal (front = 100 mg, back = 50 mg) separated by a 2-mm urethane foam plug. A silylated glass wool plug precedes the front section and a 3-mm urethane foam plug follows the back section. Pressure drop across the tube at 1 L/min airflow must be less than 3.4 kPa. Tubes are commercially available.
2. Personal sampling pumps, 0.01 to 1 L/min (Table 3), with flexible connecting tubing.
3. Gas chromatograph, FID, integrator, and column (page 1501-1).
4. Vials, glass, 1-mL, with PTFE-lined caps.
5. Pipet, 1-mL, and pipet bulb.
6. Syringes, 5-, 10-, 25- and 100-µL.
7. Volumetric flasks, 10-mL.

SPECIAL PRECAUTIONS: Carbon disulfide is toxic and extremely flammable (flash point = -30 °C); benzene is a suspect carcinogen. Prepare samples and standards in a well-ventilated hood.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break the ends of the sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.01 and 0.2 L/min (to 1 L/min for naphthalene or styrene) for a total sample size as shown in Table 3.
4. Cap the samplers with plastic (not rubber) caps and pack securely for shipment.

SAMPLE PREPARATION:

5. Place the front and back sorbent sections of the sampler tube in separate vials. Discard the glass wool and foam plugs.
6. Add 1.0 mL eluent to each vial. Attach crimp cap to each vial immediately.
7. Allow to stand at least 30 min with occasional agitation.

CALIBRATION AND QUALITY CONTROL:

8. Calibrate daily with at least six working standards over the appropriate range (ca. 0.01 to 10 mg analyte per sample; see Table 4).
   a. Add known amounts of analyte (calibration stock solution for naphthalene) to eluent in 10-mL volumetric flasks and dilute to the mark.
   b. Analyze together with samples and blanks (steps 11 through 13).
   c. Prepare calibration graph (peak area of analyte vs. mg analyte per sample).
9. Determine desorption efficiency (DE) at least once for each batch of charcoal used for sampling in the calibration range (step 8). Prepare three tubes at each of five levels plus three media blanks.

a. Remove and discard back sorbent section of a media blank sampler.
b. Inject a known amount of analyte (calibration stock solution for naphthalene) directly onto front sorbent section with a microliter syringe.
c. Cap the tube. Allow to stand overnight.
d. Desorb (steps 5 through 7) and analyze together with working standards (steps 11 through 13).
e. Prepare a graph of DE vs. mg analyte recovered.

10. Analyze three quality control blind spikes and three analyst spikes to insure that the calibration graph and DE graph are in control.

MEASUREMENT:

11. Set gas chromatograph according to manufacturer's recommendations and to conditions given on page 1501-1. Select appropriate column temperature:

Substance[a]	Approximate Retention Time (min), at Indicated Column Temperature			
	50 °C	100 °C	150 °C	Programmed[b]
benzene	2.5			2.5
toluene	4.3	1.1		4.2
xylene (para)	7.0	1.4		5.2
ethylbenzene	7.0	1.4		5.5
xylene (meta)	7.2	1.5		5.6
cumene	8.3	1.6		6.0
xylene (ortho)	10	1.9		6.5
styrene	16	2.6		7.6
α-methylstyrene		3.2	1.0	8.1
vinyltoluene (meta)		3.8	1.2	8.5
naphthalene		25	4.3	12

[a] Data not available for p-tert-butyltoluene and p-vinyltoluene.
[b] Temperature program: 50 °C for 3 min, then 15 °C/min to 200 °C.

NOTE: Alternatively, column and temperature may be taken from Table 4.

12. Inject sample aliquot manually using solvent flush technique or with autosampler.
NOTE: If peak area is above the linear range of the working standards, dilute with eluent, reanalyze and apply the appropriate dilution factor in calculations.
13. Measure peak area.

CALCULATIONS:

14. Determine the mass, mg (corrected for DE) of analyte found in the sample front (W_f) and back (W_b) sorbent sections, and in the average media blank front (B_f) and back (B_b) sorbent sections.
NOTE: If $W_b > W_f/10$, report breakthrough and possible sample loss.
15. Calculate concentration, C, of analyte in the air volume sampled, V (L):

$$C = \frac{(W_f + W_b - B_f - B_b) \cdot 10^3}{V}, \text{ mg/m}^3.$$

EVALUATION OF METHOD:

Precisions and biases listed in Table 3 were determined by analyzing generated atmospheres containing one-half, one, and two times the OSHA standard. Generated concentrations were independently verified. Breakthrough capacities were determined in dry air. Storage stability was not assessed. Measurement precisions given in Table 4 were determined by spiking sampling media with amounts corresponding to one-half, one, and two times the OSHA standard for nominal air volumes. Desorption efficiencies for spiked samplers containing only one compound exceeded 75%. Reference [9] provides more specific information.

REFERENCES:

[1] User check, UBTL, NIOSH Sequence #4121-S (unpublished, December 7, 1983).
[2] NIOSH Manual of Analytical Methods, 2nd. ed., V. 1, P&CAM 127, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-A (1977).
[3] Ibid, V. 2, S22, S23, S25, S26, S29, S30, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-B (1977).
[4] Ibid, V. 3, S292, S311, S318, S343, U.S. Department of Health, Education, and Welfare, Publ. (NIOSH) 77-157-C (1977).
[5] R. D. Dreisbach. "Physical Properties of Chemical Compounds"; Advances in Chemistry Series, No. 15; American Chemical Society, Washington (1955).
[6] Code of Federal Regulations; Title 29 (Labor), Parts 1900 to 1910; U.S. Government Printing Office, Washington (1989); 29 CFR 1910.1000.
[7] NIOSH Recommendations for Occupational Safety and Health. U.S. Department of Health and Human Services. DHHS (NIOSH) Publication No. 92-100 (1992).
[8] 1992-1993 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH, Cincinnati, OH (1992).
[9] Documentation of the NIOSH Validation Tests, S22, S23, S25, S26, S29, S30, S292, S311, S318, S343, U.S. Department of Health, Education, and Welfare; Publ. (NIOSH) 77-185 (1977).

METHOD REVISED BY:

R. Alan Lunsford, Ph.D., based on results of NIOSH Contract CDC-99-74-45.

TABLE 1. SYNONYMS, FORMULA, MOLECULAR WEIGHT, PROPERTIES [5].

Name/Synonyms	Empirical Formula	Molecular Weight	Boiling Point (°C)	Vapor Pressure @ 25 °C (mm Hg)	(kPa)	Density @ 20 °C (g/mL)
benzene CAS #71-43-2 RTECS CY1400000	C_6H_6	78.11	80.1	95.2	12.7	0.879
p-tert-butyltoluene CAS #98-51-1 1-tert-butyl-4-methylbenzene RTECS XS8400000	$C_{11}H_{16}$	148.25	192.8	0.7	0.09	0.861
cumene CAS #98-82-8 isopropylbenzene RTECS GR8575000	C_9H_{12}	120.20	152.4	4.7	0.63	0.862
ethylbenzene CAS #100-41-4 RTECS DA0700000	C_8H_{10}	106.17	136.2	9.6	1.28	0.867
α-methylstyrene CAS #98-83-9 isopropenylbenzene (1-methylethenyl)-benzene RTECS WL5075300	C_9H_{10}	118.18	165.4	2.5	0.33	0.911
naphthalene CAS #91-20-3 RTECS QJ0525000	$C_{10}H_8$	128.18	80.2[a]	0.2	0.03	1.025
styrene CAS #100-42-5 vinylbenzene RTECS WL3675000	C_8H_8	104.15	145.2	5.1	0.81	0.906
toluene CAS #108-88-3 methylbenzene RTECS XS5250000	C_7H_8	92.14	110.6	28.4	3.79	0.867
vinyltoluene[b] CAS #25013-15-4 methylstyrene (p-vinyltoluene) methylvinylbenzene RTECS WL5075000	C_9H_{10} (meta) (para) (ortho)	118.18	167.7 171.6 172.8 169.8	1.6 1.9 1.8 1.8	0.22 0.26 0.24 0.24	0.898 0.911 0.911 0.904
xylene[c] CAS #1330-20-7 dimethylbenzene (p-xylene) RTECS ZE2100000	C_8H_{10} (ortho) (meta) (para)	106.17	144.4 139.1 138.4	6.7 8.4 8.8	0.89 1.12 1.18	0.880 0.864 0.861

[a] Melting point.
[b] Commercial mixture of meta and para isomers.
[c] Mixture of isomers.

TABLE 2. PERMISSIBLE EXPOSURE LIMITS, PPM [6-8].

Substance	OSHA TWA	NIOSH TWA	NIOSH C	NIOSH STEL	ACGIH TLV	ACGIH STEL	mg/m³ per ppm
benzene	1	0.1[c]	1		10[f]		3.19
p-tert-butyltoluene	10	10		20	1		6.06
cumene	50 (skin)	50 (skin)			50 (skin)		4.91
ethylbenzene	100	100		125	100	125	4.34
α-methylstyrene	100		50			100	50 100
4.83							
naphthalene	10	10[d]		15	10	15	5.24
styrene	100	50		100	50**	100 (skin)	4.26
toluene	200	100		150	50 (skin)		3.77
vinyltoluene	100	100			50	100	4.83
xylene	100	100[e]		150	100	150	4.34

[a] Maximum duration 10 min in 8 h.
[b] Maximum duration 5 min in any 3 h.
[c] Potential carcinogen
[d] Group III Pesticide
[e] Group I Pesticide
[f] Suspect carcinogen

TABLE 3. SAMPLING FLOWRATE[a], VOLUME, CAPACITY, RANGE, OVERALL BIAS AND PRECISION [3,4,9].

Substance	Sampling Flowrate (L/min)	Sampling Volume[b] (L) MIN	Sampling Volume[b] (L) MAX	Breakthrough Volume @ Concentration (L)	Breakthrough Volume @ Concentration (mg/m³)	Range at VOL-MIN (mg/m³)	Overall Bias (%)	Overall Precision ($\hat{S}_{rT}$)	Accuracy (±%)
benzene	≤0.20	5	30	>45	149	42- 165	-0.4	0.059	11.4
p-tert-butyltoluene	≤0.20	1	29	44	112	29- 119	-10.3	0.071[d]	20.7
cumene	≤0.20	1	30	>45	480	120- 480	5.6	0.059	15.2
ethylbenzene	≤0.20	1	24	35	917	222- 884	-7.6	0.089[d]	17.1
α-methylstyrene	≤0.20	1	30	>46	940	236- 943	-7.6	0.061[d]	16.9
naphthalene[e]	≤1.0	100	200	>240	81	19- 83	-2.6	0.055	11.5
styrene	≤1.0	1	14	21	1710	426-1710	-7.9	0.058[d]	16.7
toluene	≤0.20	1	6	12	2294	548-2190	1.6	0.052	10.9
vinyltoluene	≤0.20	1	24	36	952	256- 970	-7.0	0.061[d]	16.3
xylene	≤0.20	2	23	35	870	218- 870	-1.2	0.060	12.2

[a] Minimum recommended flow is 0.01 L/min.
[b] V_{Min} = minimum sample volume @ OSHA TWA;
V_{Max} = maximum sample volume @ OSHA TWA
[c] 10-min sample.
[d] Corrected value, calculated from data in Reference 9.
[e] Naphthalene shows poor desorption efficiency at low loading; 100-L minimum volume is recommended.
[f] 15-min sample.
[g] 5-min sample.

TABLE 4. MEASUREMENT RANGE, PRECISION AND CONDITIONS[a] [3,4,9].

Substance	Desorption Volume (mL)	Measurement Range (mg)	Measurement Precision ($\hat{S}_r$)	Carrier Flow (mL/min)	Column Parameters[b] t (°C)	Column Parameters[b] Length (m)	Column Parameters[b] Packing[c]
benzene	1.0	0.09- 0.35	0.036	50	115	0.9	A
p-tert-butyltoluene	0.5	0.27- 1.09	0.021[d]	50	115	3.0	B
cumene	0.5	0.86- 3.46	0.010	50	99	3.0	B
ethylbenzene	0.5	2.17- 8.67	0.010	50	85	3.0	B
α-methylstyrene	0.5	0.89- 3.57	0.011	50	115	3.0	B
naphthalene	1.0	4.96-19.7	0.019	30	125	3.0	C
styrene	0.5	2.17- 8.49	0.013[d]	50	109	3.0	B
toluene	1.0	1.13- 4.51	0.011	50	155	0.9	D
vinyltoluene	0.5	2.41- 9.64	0.008	50	120	3.0	B
xylene	1.0	2.60-10.4	0.010	50	150	0.9	D

[a] Injection volume, 5.0 µL; nitrogen carrier gas.
[b] All columns stainless steel, 3.2-mm outside diameter.
[c] A, 50/80 mesh Porapak P; B, 10% FFAP on 80/100 mesh Chromosorb W AW-DMCS; C, 10% OV-101 on 100/120 mesh Supelcoport; D, 50/80 mesh Porapak Q.
[d] Corrected value, calculated from data in [9].

APPENDIX E

Laboratory Reports

AML
American Medical Laboratories, Inc.®
Industrial Hygiene Department
14225 Newbrook Drive
Chantilly, VA 20153
1-800-348-1590

Industrial Hygiene Laboratory
Sample Submittal Form

1) PLEASE TYPE OR USE BALL POINT PEN AND PRINT HARD.
2) THIS IS NOT A CHAIN OF CUSTODY (COC) FORM. A COC FORM IS REQUIRED FOR SAMPLES TO BE PROCESSED AS CHAIN OF CUSTODY.
3) AIR VOLUME, EXPOSURE TIME OR WIPE AREA (FOR DOSIMETERS) MUST BE PROVIDED ON THIS FORM IF CONCENTRATION RESULTS ARE TO BE REPORTED. ANALYTE MASS WILL BE REPORTED IF NO INFORMATION IS FOUND FOR THE SAMPLE.

☐ PRIORITY HANDLING **(EXTRA CHARGE WILL BE ASSESSED)**

JOB I.D. 20472 CONTACT: ERIC CHATTIPELL

* Date/Time Collected: 8/30/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-840 17279-841 17279-842 17279-843 17279-844
17279-845 17279-846 17279-847 17279-848 17279-849

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228

02 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
840	EDI A	SOLUTION A (C)		BENZENE % BY WEIGHT		
841	EDI B	SOLUTION B (1)		BENZENE % BY WEIGHT		
842	EDI C	SOLUTION C (7)		BENZENE % BY WEIGHT		
843	EDI D	SOLUTION D (30)		BENZENE % BY WEIGHT		
844						
845						
846						
847						
848						
849						

Special Conditions, Known Interferences, Comments: ATTN: ERIC PETRIE

Client Rep. Release/Date: [signature] 8/31/02

AML Receipt/Date:

Condition of Samples:

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Chantilly, VA 20153-0841
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INDUSTRIAL HYGIENE DEPARTMENT

PAGE 1 RR

RECEIVED : 08/22/2002
RELEASED : 08/27/2002
REPORTED : 08/27/2002
WORK ORDER: 180089

17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS
8785232	EPI A	MISCELLANEOUS	
3230	MISCELLANEOUS (IN-HOUSE)		
	SITE/LOCATION:	SOLUTION A (0)	
	DATE OF COLLECTION:	8/20/02	
	ANALYTE:	Benzene	
	Concentration:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.029	%
	ANALYST:	R. Kenneth Petrie	
8785233	EPI B	MISCELLANEOUS	
3230	MISCELLANEOUS (IN-HOUSE)		
	SITE/LOCATION:	SOLUTION B (1)	
	DATE OF COLLECTION:	8/20/02	
	ANALYTE:	Benzene	
	Concentration:	0.98	%
	QUANTITATION LIMIT:	0.028	%
	ANALYST:	R. Kenneth Petrie	
8785234	EPI C	MISCELLANEOUS	
3230	MISCELLANEOUS (IN-HOUSE)		
	SITE/LOCATION:	SOLUTION C (7)	
	DATE OF COLLECTION:	8/20/02	
	ANALYTE:	Benzene	
	Concentration:	6.8	%
	QUANTITATION LIMIT:	0.028	%
	ANALYST:	R. Kenneth Petrie	
8785235	EPI D	MISCELLANEOUS	
3230	MISCELLANEOUS (IN-HOUSE)		
	SITE/LOCATION:	SOLUTION D (30)	
	DATE OF COLLECTION:	8/20/02	
	ANALYTE:	Benzene	
	Concentration:	28.0	%
	QUANTITATION LIMIT:	0.028	%
	ANALYST:	R. Kenneth Petrie	

*** FINAL REPORT ***

CONTINUED ON NEXT PAGE

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
167088 R 09/01 [C-2]

NATHAN SHERMAN, M.D.
DIRECTOR OF LABORATORIES

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PAGE Z RR

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REPORTED : 08/27/2002
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17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 2247Z

AML NUMBER----------VALUE------UNITS----------

CONTINUED FROM PRIOR PAGE

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

FOR INDUSTRIAL HYGIENE RELATED QUESTIONS,
INCLUDING REQUESTS FOR SUPPLIES, CALL
1-800-348-1590

*** END OF REPORT ***

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
187086 R 09/01 (C-2)

NATHAN SHERMAN, M.D.
DIRECTOR OF LABORATORIES

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Industrial Hygiene Department
14225 Newbrook Drive
Chantilly, VA 20153
1-800-348-1590

Industrial Hygiene Laboratory
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2) THIS IS NOT A CHAIN OF CUSTODY (COC) FORM. A COC FORM IS REQUIRED FOR SAMPLES TO BE PROCESSED AS CHAIN OF CUSTODY.
3) AIR VOLUME, EXPOSURE TIME OR WIPE AREA (FOR DOSIMETERS) MUST BE PROVIDED ON THIS FORM IF CONCENTRATION RESULTS ARE TO BE REPORTED. ANALYTE MASS WILL BE REPORTED IF NO INFORMATION IS FOUND FOR THE SAMPLE.

☐ PRIORITY HANDLING **(EXTRA CHARGE WILL BE ASSESSED)**

JOB I.D. 22472 CONTACT: Rita Campion

* Date/Time Collected: 8/19/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-780	17279-781	17279-782	17279-783	17279-784
17279-785	17279-786	17279-787	17279-788	17279-789

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228

22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
780	081902 - SC01	AIR	29.204	NIOSH 1501- BENZENE		
781	081902 - SC02	AIR	29. 1146	NIOSH 1501- BENZENE		
782	081902 - SC03	AIR	29.205	NIOSH 1501- BENZENE		
783	081902 - SC04	AIR	29. 365	NIOSH 1501- BENZENE		
784	081902 - SC05	AIR	AIH			
785						
786						
787						
788						
789						

Special Conditions, Known Interferences, Comments: Special pricing - $40/sample - 3 day TAT per Chris Crane & Cindi Woodcock

Client Rep. Release/Date: [illegible] 8/22/02

AML Receipt/Date:

Condition of Samples:

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INDUSTRIAL HYGIENE DEPARTMENT

PAGE 1 RR

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REPORTED : 08/27/2002
WORK ORDER: 180121

17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS
8785358	081902-SC 01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.024	ppm
	ANALYST:	R. Kenneth Petrie	
8785359	081902-SC 02	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.024	ppm
	ANALYST:	R. Kenneth Petrie	
8785360	081902-SC 03	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.024	ppm
	ANALYST:	R. Kenneth Petrie	
8785361	081902-SC 04	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.024	ppm
	ANALYST:	R. Kenneth Petrie	
8785362	081902-SC 05	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

The calculation of analyte concentrations is based on information (i.e. air volumes, exposure times, areas,

CONTINUED ON NEXT PAGE

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
147086 R 09/01 (C-2)

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DIRECTOR OF LABORATORIES

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INDUSTRIAL HYGIENE DEPARTMENT

PAGE 2 RR

RECEIVED : 08/23/2002
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REPORTED : 08/27/2002
WORK ORDER: 180121

17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER----------VALUE-----UNITS----------

CONTINUED FROM PRIOR PAGE
etc.) provided by the client.

Unless otherwise noted in the report above, the results for the samples have not been corrected for background contamination, if found, in analysis blanks.

The current OSHA Permissible Exposure Limits (PEL) for benzene (CAS 71-43-2), (29 CFR 1910.1028):

Action Level:	0.5 ppm
Time Weighted Average, (TWA), limit:	1.0 ppm
Short-term Exposure Limit (STEL):	5.0 ppm

*** FINAL REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

FOR INDUSTRIAL HYGIENE RELATED QUESTIONS,
INCLUDING REQUESTS FOR SUPPLIES, CALL
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*** END OF REPORT ***

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
107096 R 09 01 [C-2]

NATHAN SHERMAN, M.D.
DIRECTOR OF LABORATORIES

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1-800-348-1590

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☐ PRIORITY HANDLING **(EXTRA CHARGE WILL BE ASSESSED)**

JOB I.D. 22477 CONTACT: Bill Champion

* Date/Time Collected: 08/30/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-790 17279-791 17279-792 17279-793 17279-794
17279-795 17279-796 17279-797 17279-798 17279-799

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228

22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
790	082002-BC1.01	AIR	23.4 ℓ	NIOSH 1501 BENZENE		
791	082002-BC2.01	AIR	23.76 ℓ	NIOSH 1501 BENZENE		
792	082002-BC3.01	AIR	23.04 ℓ	NIOSH 1501 BENZENE		
793	082002-BC4.01	AIR	23.28 ℓ	NIOSH 1501 BENZENE		
794	082002-BC5.01	AIR	23.52 ℓ	NIOSH 1501 BENZENE		
795	082002-BC6.010	AIR	2.97 ℓ	NIOSH 1501 BENZENE		
796	082002-BC7.010	AIR	2.95 ℓ	NIOSH 1501 BENZENE		
797	082002-BC8.010	AIR	2.98 ℓ	NIOSH 1501 BENZENE		
798	082002-BC9.011	AIR	2.97 ℓ	NIOSH 1501 BENZENE		
799	082002-BC10.011	AIR	2.95 ℓ	NIOSH 1501 BENZENE		

Special Conditions, Known Interferences, Comments: Special pricing - $40/sample - 3 day TAT Client Case - Paul Hewitt

Client Rep. Release/Date: JL Spencer 21 Aug 2002

AML Receipt/Date:

Condition of Samples:

AML
American Medical Laboratories, Inc.®
Industrial Hygiene Department
14225 Newbrook Drive
Chantilly, VA 20153
1-800-348-1590

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Sample Submittal Form

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☐ PRIORITY HANDLING (EXTRA CHARGE WILL BE ASSESSED)

JOB I.D. 22472 CONTACT: Bill Campbell

* Date/Time Collected: 02/20/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-800	17279-801	17279-802	17279-803	17279-804
17279-805	17279-806	17279-807	17279-808	17279-809

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228

22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
800	022002 - BC11.011	AIR	2.98 ℓ	NIOSH 1501 BENZENE		
801	022002 - BC12.012	AIR	2.97 ℓ	NIOSH 1501 BENZENE		
802	022002 - BC13.012	AIR	2.95 ℓ	NIOSH 1501 BENZENE		
803	022002 - BC14.012	AIR	2.98 ℓ	NIOSH 1501 BENZENE		
804	022002 - BC15.07	AIR	23.4 ℓ	NIOSH 1501 BENZENE		
805	022002 - BC16.07	AIR	23.76 ℓ	NIOSH 1501 BENZENE		
806	022002 - BC17.07	AIR	23.64 ℓ	NIOSH 1501 BENZENE		
807	022002 - BC18.07	AIR	23.28 ℓ	NIOSH 1501 BENZENE		
808	022002 - BC19.07	AIR	23.52 ℓ	NIOSH 1501 BENZENE		
809	022002 - BC20.070	AIR	3.17 ℓ	NIOSH 1501 BENZENE		

Special Conditions, Known Interferences, Comments: Special pricing - 40/sample -
3 day TAT Per Chris Clark - Carol Woodruff

Client Rep. Release/Date: Bill Spencer / 21 Aug 2002
AML Receipt/Date:
Condition of Samples:

AML
American Medical Laboratories, Inc.®
Industrial Hygiene Department
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Chantilly, VA 20153
1-800-348-1590

Industrial Hygiene Laboratory
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☐ PRIORITY HANDLING **(EXTRA CHARGE WILL BE ASSESSED)**

JOB I.D. 22472 CONTACT: Kim Campion

* Date/Time Collected: 8/20/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-810 17279-811 17279-812 17279-813 17279-814
17279-815 17279-816 17279-817 17279-818 17279-819

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228
22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
810	082002-BC01.070	AIR	3.15 L	NIOSH 1501 BENZENE		
811	082002-BC02.070	AIR	3.18 L	NIOSH 1501 BENZENE		
812	082002-BC03.071	AIR	2.97 L	NIOSH 1501 BENZENE		
813	082002-BC04.071	AIR	2.95 L	NIOSH 1501 BENZENE		
814	082002-BC05.071	AIR	2.98 L	NIOSH 1501 BENZENE		
815	082002-BC06.072	AIR	2.97 L	NIOSH 1501 BENZENE		
816	082002-BC07.072	AIR	2.95 L	NIOSH 1501 BENZENE		
817	082002-BC08.072	AIR	2.98 L	NIOSH 1501 BENZENE		
818	082002-BC09.30	AIR	23.56 L	NIOSH 1501 BENZENE		
819	082002-BC~~10~~ 30.30	AIR	23.96 L	NIOSH 1501 BENZENE		

Special Conditions, Known Interferences, Comments: Special Pricing - $10/sample -
3 day TAT, per Chris Chase & Carl Woodruff

Client Rep. Release/Date: [signature] / 21 Aug 2002
AML Receipt/Date:
Condition of Samples:

AML
American Medical Laboratories, Inc.®
Industrial Hygiene Department
14225 Newbrook Drive
Chantilly, VA 20153
1-800-348-1590

Industrial Hygiene Laboratory Sample Submittal Form

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☐ PRIORITY HANDLING (EXTRA CHARGE WILL BE ASSESSED)

JOB I.D. 22472 CONTACT: Eric Champion

* Date/Time Collected: 8/20/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-820	17279-821	17279-822	17279-823	17279-824
17279-825	17279-826	17279-827	17279-828	17279-829

17279
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228
22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
820	080002-BC36.30	AIR	23.04 ℓ	NIOSH 1501 BENZENE		
821	080003-BC32.30	AIR	22.28 ℓ	NIOSH 1501 BENZENE		
822	080004-BC33.30	AIR	23.52 ℓ	NIOSH 1501 BENZENE		
823	080005-BC34.300	AIR	2.97 ℓ	NIOSH 1501 BENZENE		
824	080006-BC35.300	AIR	2.95 ℓ	NIOSH 1501 BENZENE		
825	080007-BC36.300	AIR	2.98 ℓ	NIOSH 1501 BENZENE		
826	080008-BC37.301	AIR	2.97 ℓ	NIOSH 1501 BENZENE		
827	080009-BC38.301	AIR	2.95 ℓ	NIOSH 1501 BENZENE		
828	080010-BC39.301	AIR	3.18 ℓ	NIOSH 1501 BENZENE		
829	080011-BC40.302	AIR	2.97 ℓ	NIOSH 1501 BENZENE		

Special Conditions, Known Interferences, Comments: Special pricing - $40/sample -
2 day TAT per Chris Case - Coastal Horizons

Client Rep. Release/Date: [signature] / 21 Aug 2002
AML Receipt/Date:
Condition of Samples:

American Medical Laboratories, Inc.®
Industrial Hygiene Department
14225 Newbrook Drive
Chantilly, VA 20153
1-800-348-1590

Industrial Hygiene Laboratory
Sample Submittal Form

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☐ PRIORITY HANDLING **(EXTRA CHARGE WILL BE ASSESSED)**

JOB I.D. 02472 CONTACT: Bill Campbell

* Date/Time Collected: 2/20/02

** Required for drinking water samples*

PEEL OFF LABEL FROM INSIDE CORNER AND PLACE LABEL ON SAMPLE(S)

PLEASE NOTE:
CHAIN OF CUSTODY FORMS AVAILABLE UPON REQUEST.

17279-830	17279-831	17279-832	17279-833	17279-834
17279-835	17279-836	17279-837	17279-838	17279-839

17279 PV
ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE, MD 21228

22 FEB 2002

Sticker #	Sample ID	Sample Description/Source	Air Volume / Exp. Time / Wipe Area	Analysis Requested	AML Number	Type
830	080002-BC41.302	AIR	2.95 L	NIOSH 1501 BENZENE		
831	080002-BC42.302	AIR	2.98 L	NIOSH 1501 BENZENE		
832	080002-BLANK 1		NA	NIOSH 1501 BENZENE		
833	080002-BLANK 2		NA	NIOSH 1501 BENZENE		
834						
835						
836						
837						
838						
839						

Special Conditions, Known Interferences, Comments: Special pricing - $40/sample - 2 day TAT per Chris Case, Carol Headcutt

Client Rep. Release/Date: [signature] / 21 Aug 2002

AML Receipt/Date:

Condition of Samples:

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RECEIVED : 08/22/2002 ITZTY ENVIRONMENTAL PROFILES
RELEASED : 08/23/2002 ATTN: JOHN SPENCER
REPORTED : 08/23/2002 813 FREDERICK RD
WORK ORDER: 180084 BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 2247Z

AHL NUMBER		VALUE	UNITS
8780188	082002-BC1.01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	57.0	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.762	ppm
	ANALYST:	R. Kenneth Petrie	
8780189	082002-BC2.01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	50.9	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.670	ppm
	ANALYST:	R. Kenneth Petrie	
8780190	082002-BC3.01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	10	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.14	ppm
	ANALYST:	R. Kenneth Petrie	
8780191	082002-BC4.01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	8.0	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.11	ppm
	ANALYST:	R. Kenneth Petrie	
8780192	082002-BC5.01	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	7.7	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.10	ppm
	ANALYST:	R. Kenneth Petrie	
8780193	082002-BC6.010	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	9.5	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.0	ppm

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PROJECT NAME/JOB ID: 2247Z

AML NUMBER		VALUE	UNITS
	CONTINUED FROM PRIOR PAGE		
	ANALYST:	R. Kenneth Petrie	
8755174	082002-BC7.010	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	8.0	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.85	ppm
	ANALYST:	R. Kenneth Petrie	
8755175	082002-BC8.010	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	2.6	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.27	ppm
	ANALYST:	R. Kenneth Petrie	
8755176	082002-BC9.011	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	10	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.1	ppm
	ANALYST:	R. Kenneth Petrie	
8755177	082002-BC10.011	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	10	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.1	ppm
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

The calculation of analyte concentrations is based on information (i.e. air volumes, exposure times, areas, etc.) provided by the client.

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The current OSHA Permissible Exposure Limits (PEL) for

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REPORTED : 08/23/2002 813 FREDERICK RD
WORK ORDER: 180084 BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS
	CONTINUED FROM PRIOR PAGE		
	benzene (CAS 71-43-2), (29 CFR 1910.1028):		
	Action Level:	0.5	ppm
	Time Weighted Average, (TWA), limit:	1.0	ppm
	Short-term Exposure Limit (STEL):	5.0	ppm

*** FINAL REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

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PROJECT NAME/JOB ID: 2247Z
:

AML NUMBER		VALUE	UNITS
8783198	08Z002-BC11.01I	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.24	ppm
	ANALYST:	R. Kenneth Petrie	
8783199	08Z002-BC12.01Z	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	8.5	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.90	ppm
	ANALYST:	R. Kenneth Petrie	
8783209	08Z002-BC13.01Z	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	7.9	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.84	ppm
	ANALYST:	R. Kenneth Petrie	
8783201	08Z002-BC14.01Z	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.24	ppm
	ANALYST:	R. Kenneth Petrie	
8783208	08Z002-BC15.01	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	113	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.51	ppm
	ANALYST:	R. Kenneth Petrie	
8783202	08Z002-BC16.01	CHARCOAL TUBE	
1034	BENZENE (71-43-2)		
	MASS:	98.7	ug

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PROJECT NAME/JOB ID: 2247Z

AML NUMBER		VALUE	UNITS
	CONTINUED FROM PRIOR PAGE		
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.30	ppm
	ANALYST:	R. Kenneth Petrie	
07[illegible]204	082002-BC17.OT	CHARCOAL TUBE	
1334	BENZENE (71-43-2)		
	MASS:	18	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.24	ppm
	ANALYST:	R. Kenneth Petrie	
07[illegible]205	082002-BC18.OT	CHARCOAL TUBE	
1334	BENZENE (71-43-2)		
	MASS:	22.4	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.301	ppm
	ANALYST:	R. Kenneth Petrie	
07[illegible]206	082002-BC19.OT	CHARCOAL TUBE	
1334	BENZENE (71-43-2)		
	MASS:	24.0	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.314	ppm
	ANALYST:	R. Kenneth Petrie	
07[illegible]207	082002-BC20.OTO	CHARCOAL TUBE	
1334	BENZENE (71-43-2)		
	MASS:	50.9	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	5.03	ppm
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

The calculation of analyte concentrations is based on information (i.e. air volumes, exposure times, areas, etc.) provided by the client.

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PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS

CONTINUED FROM PRIOR PAGE

The current OSHA Permissible Exposure Limits (PEL) for benzene (CAS 71-43-2), (29 CFR 1910.1028):

Action Level:	0.5 ppm
Time Weighted Average, (TWA), limit:	1.0 ppm
Short-term Exposure Limit (STEL):	5.0 ppm

*** FINAL REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

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WORK ORDER: 180086 BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER			VALUE	UNITS
8785208	082002-BC21.070	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		47.3	ug
	QUANTITATION LIMIT:		2.2	ug
	CONCENTRATION:		4.70	ppm
	ANALYST:		R. Kenneth Petrie	
8785209	082002-BC22.070	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		9.3	ug
	QUANTITATION LIMIT:		2.2	ug
	CONCENTRATION:		0.92	ppm
	ANALYST:		R. Kenneth Petrie	
8785210	082002-BC23.071	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		12	ug
	QUANTITATION LIMIT:		2.2	ug
	CONCENTRATION:		1.3	ppm
	ANALYST:		R. Kenneth Petrie	
8785211	082002-BC24.071	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		9.7	ug
	QUANTITATION LIMIT:		2.2	ug
	CONCENTRATION:		1.0	ppm
	ANALYST:		R. Kenneth Petrie	
8785212	082002-BC25.071	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		Less than quantitation limit.	
	QUANTITATION LIMIT:		2.2	ug
	CONCENTRATION:		Less than quantitation limit.	
	QUANTITATION LIMIT:		0.24	ppm
	ANALYST:		R. Kenneth Petrie	
8785213	082002-BC26.072	CHARCOAL TUBE		
1534	BENZENE (71-43-2)			
	MASS:		12	ug
	QUANTITATION LIMIT:		2.2	ug

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PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS
	CONTINUED FROM PRIOR PAGE		
	CONCENTRATION:	1.3	ppm
	ANALYST:	R. Kenneth Petrie	
8785214	082002-BC27.072	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	11	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.2	ppm
	ANALYST:	R. Kenneth Petrie	
8785215	082002-BC28.072	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	Less than quantitation limit.	
	QUANTITATION LIMIT:	0.24	ppm
	ANALYST:	R. Kenneth Petrie	
8785216	082002-BC29.30	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	205	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	2.72	ppm
	ANALYST:	R. Kenneth Petrie	
8785217	082002-BC30.30	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	147	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.92	ppm
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

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PROJECT NAME/JOB ID: 22472

AML NUMBER----------VALUE-----UNITS----------

CONTINUED FROM PRIOR PAGE

The current OSHA Permissible Exposure Limits (PEL) for benzene (CAS 71-43-2), (29 CFR 1910.1028):

Action Level:	0.5 ppm
Time Weighted Average, (TWA), limit:	1.0 ppm
Short-term Exposure Limit (STEL):	5.0 ppm

*** FINAL REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

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PROJECT NAME/JOB ID: 22472

ANL	NUMBER		VALUE	UNITS
E	85218	082002-BC31.30	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	47.0	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	0.638	ppm
		ANALYST:	R. Kenneth Petrie	
E	85219	082002-BC32.30	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	5.6	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	0.14	ppm
		ANALYST:	R. Kenneth Petrie	
E	85220	082002-BC33.30	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	5.5	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	0.14	ppm
		ANALYST:	R. Kenneth Petrie	
E	85221	082002-BC34.300	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	22.4	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	2.36	ppm
		ANALYST:	R. Kenneth Petrie	
E	85222	082002-BC35.300	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	13	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	1.4	ppm
		ANALYST:	R. Kenneth Petrie	
E	85223	082002-BC36.300	CHARCOAL TUBE	
	1534	BENZENE (71-43-2)		
		MASS:	2.2	ug
		QUANTITATION LIMIT:	2.2	ug
		CONCENTRATION:	0.23	ppm

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PROJECT NAME/JOB ID: ZZ47Z

ANALYSIS NUMBER		VALUE	UNITS
	CONTINUED FROM PRIOR PAGE		
	ANALYST:	R. Kenneth Petrie	
E 85224	082002-BC37.301	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	17	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	2.0	ppm
	ANALYST:	R. Kenneth Petrie	
E 85225	082002-BC38.301	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	18	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	1.9	ppm
	ANALYST:	R. Kenneth Petrie	
E 85226	082002-BC39.301	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	5.2	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	0.51	ppm
	ANALYST:	R. Kenneth Petrie	
E 85227	082002-BC40.302	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	33.5	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	3.53	ppm
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

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The current OSHA Permissible Exposure Limits (PEL) for

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PROJECT NAME/JOB ID: 22472

ANALYTE NUMBER	VALUE	UNITS

CONTINUED FROM PRIOR PAGE

benzene (CAS 71-43-2), (29 CFR 1910.1028):

Action Level:	0.5	ppm
Time Weighted Average, (TWA), limit:	1.0	ppm
Short-term Exposure Limit (STEL):	5.0	ppm

*** REASON FOR CORRECTION ***

corrected for change in air volume

*** CORRECTED REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

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1-800-348-1590

*** END OF REPORT ***

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
167086 R 08/01 [C-2]

NATHAN SHERMAN, M.D.
DIRECTOR OF LABORATORIES

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INDUSTRIAL HYGIENE DEPARTMENT

PAGE 1 RR

RECEIVED : 08/22/2002
RELEASED : 08/27/2002
REPORTED : 08/27/2002
WORK ORDER: 180088

17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS
8785228	082002-BC41.302	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	32.9	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	3.49	ppm
	ANALYST:	R. Kenneth Petrie	
8785229	082002-BC42.302	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	20	ug
	QUANTITATION LIMIT:	2.2	ug
	CONCENTRATION:	2.1	ppm
	ANALYST:	R. Kenneth Petrie	
8785230	082002-BLANK 1	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	ANALYST:	R. Kenneth Petrie	
8785231	082002-BLANK 2	CHARCOAL TUBE	
1534	BENZENE (71-43-2)		
	MASS:	Less than quantitation limit.	
	QUANTITATION LIMIT:	2.2	ug
	ANALYST:	R. Kenneth Petrie	

NOTATIONS

The calculation of analyte concentrations is based on information (i.e. air volumes, exposure times, areas, etc.) provided by the client.

Unless otherwise noted in the report above, the results for the samples have not been corrected for background contamination, if found, in analysis blanks.

The current OSHA Permissible Exposure Limits (PEL) for benzene (CAS 71-43-2), (29 CFR 1910.1028):

Action Level:	0.5 ppm
Time Weighted Average, (TWA), limit:	1.0 ppm
Short-term Exposure Limit (STEL):	5.0 ppm

CONTINUED ON NEXT PAGE

Age and sex dependent reference ranges are printed when available if age and sex are designated. Otherwise, adult values are given.
167088 R 09/01 [C-Z]

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INDUSTRIAL HYGIENE DEPARTMENT

PAGE 2 RR

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17279 ENVIRONMENTAL PROFILES
ATTN: JOHN SPENCER
813 FREDERICK RD
BALTIMORE , MD 21228

PROJECT NAME/JOB ID: 22472

AML NUMBER		VALUE	UNITS

CONTINUED FROM PRIOR PAGE

*** FINAL REPORT ***

CHRISTOPHER KASE, CAIH
DIRECTOR, IND. HYGIENE

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*** END OF REPORT ***

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167086 R 08/01 (C-2)

NATHAN SHERMAN, M.D.
DIRECTOR OF LABORATORIES

APPENDIX F

Assessment Study Field Notes

ENVIRONMENTAL PROFILES, INC.
813 Frederick Road
Baltimore, MD 21228
410-744-0700
410-744-2003 FAX

FIELD REPORT

Project No: 22473 Date: 8/30/02

Client: NELSON MULLINS RILEY + SCARBOROUGH Temperature: 83° @ 0945.

Project: LIQUID WRENCH Relative Humidity: 53%

Location: 3900 VERO RD BALTIMORE MD Prepared By: Bob Champion

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

PUMP DESIGNATION - LB - 1 + 2, JS - 3, AREA - 4.
0922 - SETTING UP FOR EXPOSURE ASSESSMENT -
0939 - MARKING SAMPLING TUBES LABELS, PUTTING ON PUMPS, TUBES, ET.
0945 - START TIME - DISPLAYING VALVES, LIQUID WRENCH 1% PRODUCT, PUMPS
0947 STARTING PUMPS - 2h-SAMPLES BEGIN.
0948 - JS TAKES ANEMOMETER READING (0 - 1 FT/min)
0949 - LB BEGINS SCRAPING RUST FROM BOLTS ON VALVE ASSEMBLY
0952 - LB - STEL(1%) STARTED ON P1, P2.
0953 - JS - STEL(1%) STARTED ON P3.
0954 - LB - BEGINS APPLYING 1% LIQUID WRENCH PRODUCT TO THE FLANGE ON THE VALVE ASSEMBLY (BOLTS) - JS IS AT HIS ELBOW (~3FT)
0955 - LB TAPS BOLTS ON FLANGE, THEN APPLIES MORE LIQUID WRENCH PRODUCT
- JS ASSISTS BY SCRAPING AT A BOLT
0956 - LB USES WRENCHES TO ATTEMPT TO LOOSEN BOLTS.
- NOT LOOSENED ENOUGH - LB APPLIES MORE LW TO BOLT.
1002 - LB CONTINUES TO WORK ON BOLTS - VERY TIGHT
1003 - LB APPLIES LW AGAIN TO THREE BOLTS ON SAME FLANGE.
1004 - LB REAPPLIES LW TO BOLTS AND TAPS WITH HAMMER
1007 - JS CHANGES STEL SAMPLE TUBE ON LB (P1, [redacted]) (STEL 2-STOP)
1008 - JS CHANGES STEL SAMPLE TUBE ON LB (P2) (STEL 2-START)
1009 - JS CHANGES STEL ON HIS SAMPLER (P3) (STEL 2-START)
1011 - PUT CAPS ON THE FIRST 3 STEL SAMPLE TUBES AND PLACED IN ENVELOPE.
1011 - LB BEGINS APPLYING LW TO 2ND FLANGE ASSEMBLY
1012 - LB TAPS BOLTS WITH HAMMER TO LOOSEN.
1020 - LB APPLIES MORE LW + TAPS BOLTS.
- JS GIVES SAFETY GLASSES TO LB W/
1022 - JS CHANGES STEL SAMPLE TUBE ON P1 (STEL 3-START)
1023 - JS CHANGES STEL SAMPLE TUBE ON P2 (STEL 3-START)
1024 - JS CHANGES STEL SAMPLE TUBE ON P3 (OWN) (STEL 3-START)

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FIELD REPORT

Project No: 224772 Date: 8/30/02

Client: NELSON MULLINS RILEY & SCARBOROUGH Temperature:

Project: LIQUID WRENCH Relative Humidity:

Location: 3400 VERO RD BALTIMORE MD Prepared By: BILL CAMPION

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

1025 LB BEGINS APPLYING MORE LW TO FLANGES (ALL 3 IN SUCCESSION)
1026 JS PHOTO OF LB APPLYING LW
1027 LB CONTINUES TO APPLY LW - BOLTS ARE RESISTING LOOSENING
LB SCRAPES BOLTS WITH WIRE BRUSH AND TAPS W/ HAMMER
1028 JS MOVES BEHIND TABLE TO ASSIST.
1029 LB ALLOWS LW TO PENETRATE
1036 LB APPLIES MORE LW TO BOLTS (BOTTLE A IS NEARLY EMPTY)
(EACH OF TWO BOTTLES OF LW FOR 1%, 7%, 30% IS LABELED EITHER A OR B)
1037 LB WAITS FOR LW TO PENETRATE
1034 LB TAPS BOLTS WITH HAMMER
1037 JS STOPS STEEL SAMPLE TUBE - (P1) ON LB
1038 JS STOPS STEEL SAMPLE TUBE (P2) ON LB
1039 JS STOPS STEEL SAMPLE TUBE (P3) (OWN)
1040 LB APPLIES MORE LW TO BOLTS
1041 LB SCRAPES WITH WIRE BRUSH & TAPS WITH HAMMER TO ATTEMPT TO LOOSEN BOLTS.
1044 JS REPORTS THAT APPROXIMATELY 185 ml LW (1%) WAS USED ON FLANGE / BOLTS DURING FIRST HOUR.
1045 - LB APPLIES MORE LW TO BOLTS
- LB HAS EMPTIED THE 1% BOTTLE A LW PREPARATION
1047 - LB CONTINUES TO SCRAPE AND TAP THE BOLTS
1055 - LB WAITS FOR LW TO PENETRATE
1057 - LB TAKES BREAK IN SAME AREA (SITS FOR ONE MINUTE)
1059 - LB BACK AT TABLE, PUTS ON GLOVES AND TRIES TO LOOSEN BOLTS
TEMP - 81.7°F, HUMIDITY - 53%
11:00 LB APPLIES MORE 1% LW TO BOLTS
JS COLLECTS
11:05 - LB RESORTS TO BREAKER BAR TO ATTEMPT TO LOOSEN BOLT

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Baltimore, MD 21228
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FIELD REPORT

Project No: 22472 Date: 8/30/02

Client: NELSON MULLINS RILEY + SCARBOROUGH Temperature:

Project: BENZENE EXPOS. ASSESSMENT Relative Humidity:

Location: 3900 VERO RD BALTIMORE MD Prepared By: BILL CAMPIONI

Work in Progress: EXPOSURE ASSESSMENT- LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

1110 - LB FINALLY SUCCEEDS TO REMOVE ONE BOLT.
1111 - LB's PUMP (P2) COMES OFF HIS BELT - JS HELPS GET IT BACK IN CORRECT POSITION.
1112 - LB APPLIES MORE LW TO BOLTS
1132 - LB TRIES TO LOOSEN ANOTHER BOLT
- JS ASSISTS BY HOLDING FLANGE ASSEMBLY
1135 - LB - JS CONTINUE TO WORK ON FLANGE BOLTS - LB WITH WRENCH AND HAMMER, JS HOLDING DOWN FLANGE ASSEMBLY
1132 - LB + JS - CONTINUE TO WORK - HAVING SOME SUCCESS NOW AT LOOSENING BOLTS USING HAMMER TO TAP WRENCH.
1133 - LB REAPPLIES 7% LW TO BOLTS.
1140 - LB CONTINUES TO WORK ON BOLTS - LOOSENING W/ WRENCH AND HAMMER
1147 - JS SHUTS OFF SAMPLING PUMPS + COLLECTS SAMPLE TUBES FOR 2hr SAMPLES - (P1, P2, P3, P4).
1150 - TUBES CAPPED, CLEAN UP BEGINS OF TABLE AREA AND TOOLS.
~~BE~~1200 - BREAK FOR LUNCH, CLEAN UP OF TABLE AREA + TOOLS DONE.
(STEEL SAMPLES - TUBES UP, PUMP # VISIBLE - STEEL ON RIGHT)
1220 - PUMPS SET UP, TUBES ARRANGED FOR 7% LW.
1225 - START SAMPLING - LB - P1, P2, (STEEL 1)
1226 - START SAMPLING - JS - P3 AR - P4 (+ STEEL 1)
1227 - LB APPLIES LW 7% PRODUCT TO NEW FLANGE ASSEMBLY
1229 - LB BEGINS TAPPING BOLTS WITH HAMMER
1235 - LB TRIES BOLTS AGAIN W/ WRENCH & RATCHET
12:37 - TEMP: 82.8° F, HUMIDITY 52.6%, CO_2 659 ppm
1239 - JS ASSISTS FROM ~ 5 FT AWAY.
12140 - LB APPLIES MORE 7% LW TO BOLTS.
- LB IS HAVING SUCCESS REMOVING BOLTS W/ WRENCH & HAMMER
12:42 - JS COLLECTS SAMPLE TUBE FROM P1, P2, P3 (STEEL 1) (1141, 1242)
12:44 - JS STARTS STEEL 2 SAMPLES ON P1, P2, P3 (STEEL 2)

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FIELD REPORT

Project No: 22472 Date: 8/30/02

Client: NELSON MULLINS RILEY + SCARBOROUGH Temperature:

Project: BENZENE EXPOS ASSESS. Relative Humidity:

Location: 3400 VERO RD BALTIMORE MD Prepared By: BILL CHAMPION

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

1245 - LB APPLIES MORE 7% LW TO BOLTS.
1247 - LB USES HAMMER AND WRENCH TO LOOSEN BOLTS.
1259 - LB CONTINUES WORKING ON REMOVING BOLTS W/ WRENCH + RATCHET + HAMMER.
1255 - LB CONTINUES WORKING ON BOLTS WITH TOOLS
1259 - JS COLLECTS STEL 2 SAMPLE TUBES FROM P1, P2, P3.
1300 - LB CONTINUES LOOSENING WITH WRENCH + HAMMER TO LOOSEN BOLTS - STEL 2 TUBES CAPPED AND STORED.
1305 - LB PAUSES FOR COLD WATER
1306 - LB BACK AT WORK WITH WRENCHES REMOVING BOLTS.
1308 - LB TIGHTENS BOLTS THAT WERE LOOSENED.
1312 - JS STARTS STEL 3 SAMPLE TUBES - (P1, P2) ON LB
1313 - JS STARTS STEL 2 SAMPLE TUBES (P3) + OWN
1313 - LB APPLIES 7% LW TO LAST FLANGE ON THIS ASSEMBLY
1314 - LB APPLIES 7% LW TO FRONT OF FLANGE (BOLTS)
1315 - LB + JS WAIT FOR LW (7%) TO PENETRATE LAST BOLTS - STAY WITHIN 10 FT OF FLANGE.
1317 - LB BACK TO FLANGE - BEGINS USING WRENCH AND HAMMER TO TRY TO LOOSEN BOLTS.
1318 - FIRST BOLTS LOOSENS ON LAST FLANGE.
1322 - LB CONTINUES TO WORK ON LOOSENING BOLTS.
1328-3 - LB APPLIES 7% LW TO BOLTS AGAIN
1324 - LB USES WRENCH ON BOLTS, TAPS WITH HAMMER
1327 - JS STORS STEL 3 SAMPLES ON LB (P1, P2)
1328 - JS STOPS STEL 3 SAMPLE ON OWN (P3)
1328 - LB CONTINUES WORKING ON LOOSENING BOLTS ON LAST FLANGE
1330 - LB - ALL BOLTS LOOSE ON FLANGE
1332 - LB BREAKS FOR COLD WATER
1333 - Temp: - 82 °F RH 53 %
- JS REPORTS LB USED ~ 1/2 4 FL OZ CONTAINER TO LOOSEN BOLTS ON LAST FLANGE.

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FIELD REPORT

Project No: 22472 Date: 8/20/02

Client: NELSON MULLINS RILEY SCARBOROUGH Temperature:

Project: BENZENE EXPOS. ASSESSMENT Relative Humidity:

Location: 3900 VERO RD BALTIMORE MD Prepared By: BILL CAMPION

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

1333 - LB TIGHTENS BOLTS ON LAST FLANGE.
1340 - LB HAS FINISHED TIGHTENING 6 BOLTS. (3 FLANGES)
1343 - LB APPLIES MORE 7% LW TO ALL BOLTS ON 40HOLE ASSEMBLY
1344 - LB-JS WAIT FOR LW TO PENETRATE -
1348 - LB BRINGS FLANGE ASSEMBLY THAT WAS USED FOR THE 1% LW TESTING BACK TO TABLE TO SEE IF THE 7% CAN FREE UP THE BOLTS.
1349 - LB SCRAPES FLANGE WITH WIRE BRUSH, TAPS BOLTS W/HAMMER
1350 - LB APPLIES 7% LW TO BOLTS
1350 - LB USES WRENCHES AND HAMMER TO WORK ON LOOSENING BOLT
1355 - LB APPLIES 7% LW TO BOLTS AGAIN, THEN WORKS TO LOOSEN
1402 - LB APPLIES 7% LW TO BOLTS AGAIN
1407 - BLANK 2 - OPENED ENDS, WAITED 30 SECONDS - THEN CAPPED
1408 - BLANK 1 - OPENED ENDS, WAITED 30 SECONDS - THEN CAPPED (BLANKS WERE OPENED ~ 10 ft FROM TABLE)
1410 - LB WORKS ON BOLTS WITH WRENCH + HAMMER
1433 - JS STORE 3 hr SAMPLES (7%), 1426 P3, P4
(48) 1425 - PREP FOR TEST 3
1433 ~~1438~~ - JS STARTS SAMPLES ON LB (P1, P2) (STEEL-1)
1434 ~~1439~~ - JS STARTS SAMPLES ON ELBOW + AREA (P3, P4) (STEEL 1)
1435 - LB APPLIES 30% LW PRODUCT TO NEW (OLD) FLANGE ASSEMBLY
1436 - LB USES HAMMER TO TAP FLANGES & BOLTS
TEMP - 82°F, RH - 53.2%
1439 - LB USES WRENCH + HAMMER TO LOOSEN BOLTS - HAVING SUCCESS.
1442 - LB CONTINUES TO LOOSEN BOLTS, JS ~ 3ft from FLANGE.
1446 - LB CONTINUES TO LOOSEN BOLTS, JS ~ 2ft from FLANGES.
(503) 1448 - JS CHANGES STEEL 1 SAMPLE TUBES (P1, P2)
1449 - JS STARTS STEEL 2 SAMPLES TUBES (P1, P2)
1449 - JS CHANGES + STARTED OLD STEEL SAMPLE (P3)
1450 - LB APPLIES 30% LW TO BOLTS ON FLANGE

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FIELD REPORT

Project No: 22472 Date: 8/30/07

Client: NELSON/MULLINS RILEY & SCARBOROUGH Temperature:

Project: BENZENE EXPOS. ASSESSMENT Relative Humidity:

Location: 3900 VERO RD BALTIMORE MD Prepared By: BILL CAMPION

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH/BENZENE

OBSERVATIONS AND COMMENTS

1451 - LB TAPS BOLTS W/TH HAMMER
1452 - LB APPLIES 30% LW TO BOLTS, JS ~ 3FT FROM FLANGE
1453 - LB CONTINUES TO LOOSEN BOLTS WITH WRENCH & HAMMER
1503 - JS STOPS STEL 2 (P1, P2)
1504 - JS STARTS STEL 3 (P1, P2)
1505 - JS CHANGES OWN STEL 2 to STEL 3 TUBES.
1506 - LB APPLIES 30% LW TO FLANGE, JS ~ 3FT FROM FLANGE
1610 - LB APPLIES 30% LW TO FLANGE.
- LB USES WRENCH & HAMMER TO LOOSEN BOLTS
1514 - LB CONTINUES TO LOOSEN BOLTS
1519 - JS STORS STEL 3 ON LB (P1, P2)
1500 JS STOPS STEL 3 ON OWN (P3)
1521 - LB APPLIES MORE 30% LW TO BOLTS
1525 - LB CONTINUES TO LOOSEN BOLTS
1528 - LB BREAKS FOR COLD WATER
1534 - LB BACK AT WORK LOOSENING BOLTS, TAPPING WITH HAMMER
1537 - PUMP #4 SHUT OFF - ASSUME BATTERY DIED.
- COLLECTED SAMPLES BC33 & BC33 AND CAPPED THEM.
1543 - LB SWITCHES OUT FLANGE ASSEMBLIES - BRINGS BACK FIRST ASSEMBLY THAT WAS LOOSED ON (1% LW ASSESSMENT)
1544 - LB TAPS BOLTS ON FIRST FLANGE ASSEMBLY
1545 - LB BREAKS FOR COUPLE OF MINUTES
1552 - LB RETURNS TO TAPPING FLANGE BOLTS WITH HAMMER
1553 - LB SCRAPES WITH WIRE BRUSH
1554 - LB APPLIES 30% LW TO FIRST FLANGE ASSEMBLY BOLTS.
1556 - JS REPORTS LB HAS USED 1/2 OF 4FL OZ BOTTLE (A) DURING THIS ASSESSMENT (~63mL)
1557 - LB WAITING FOR LW TO PENETRATE
1559 - LB BACK AT TABLE WITH WRENCH & HAMMER TRYING TO LOOSEN BOLTS.

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FIELD REPORT

Project No: 22477 Date: 8/20/02

Client: NELSON MULLINS RILEY + SCARBOROUGH Temperature:

Project: BENZENE EXPOS. ASSESSMENT Relative Humidity:

Location: 3900 VERO RD BALTIMORE MD Prepared By: BILL CAMPION

Work in Progress: EXPOSURE ASSESSMENT - LIQUID WRENCH / BENZENE

OBSERVATIONS AND COMMENTS

1603 - LB APPLIES MORE 30% LW TO FLANGE BOLTS
1604 - LB USES WRENCH + HAMMER TO ATTEMPT TO LOOSEN BOLT.
1605 - JS USES BREAKER BAR IN ASSIST TO ASSIST LB IN LOOSENING BOLT
1613 - LB APPLIES MORE 30% LW TO FLANGE BOLTS AND THEN WAITS FOR IT TO WORK.
1618 - LB APPLIES MORE 30% LW TO FLANGE BOLTS
1625 - LB TAPS BOLTS WITH HAMMER
1627 - LB USES WRENCHES TO TRY TO LOOSEN BOLTS
1630 - TEMP 80.8°F, RH 53.3%
1632 - STOPPING WATER
1633 - STOPPING AREA AND 2 IN. SAMPLES.
1634 - JS COLLECTS SAMPLES FROM LB (P1, P2)
- JS COLLECTS OIL SAMPLE (P3)

APPENDIX IV:

Summary Report
"Determination of Evaporation Rates for a Benzene-Containing Solvent Mixture"

Summary Report

Determination of Evaporation Rate for a Benzene-Containing Solvent Mixture

EPI Project No. 29125

Prepared For:

Mr. Tim Gray, Esquire
Forman, Perry, Watkins, and Krutz & Tardy LLP
200 South Lamar Street
City Centre Building, Suite 100
Jackson, MS 39201-4099

9 July 2009

Prepared by:

ENVIRONMENTAL PROFILES, INC.
8805 Columbia 100 Parkway, Suite 100
Columbia, Maryland 21045
(410) 744-0700
(410) 744-2003 Fax

STUDY OBJECTIVE/PURPOSE

Many of the products used in residential, commercial, and industrial applications contain mixed hydrocarbon solvents and, historically, these hydrocarbon mixtures could have contained benzene at varying concentrations. The rate at which the benzene evaporates from these mixtures is dependant on several factors including the components of the mixture. Raoult's law applied to ideal solutions is used to estimate the rate at which the benzene evaporates out of mixed hydrocarbon solutions. However, as Elkins and Pagnatto (1963) determined in the 1960s, other hydrocarbons in the mixture positively or negatively affect the evaporation rate of benzene from the solution.

The purpose of this study was to determine the evaporation rate of benzene from a penetrating solvent product manufactured and marketed in the 1960 through1978 timeframe. The product that was examined was a historic formulation of Liquid Wrench, which consisted of oil dispersed in a solvent based material designed to assist in the removal of rusted and corroded bolts and fittings. In order to determine the evaporation rate of benzene in a Liquid Wrench formulation, benzene in the Liquid Wrench formulation evaporated under controlled conditions while the airborne concentration of benzene was evaluated over time. The concentration of benzene in a specified volume of air per unit time was then converted to mass of benzene per unit of time, thereby determining the mass loss of benzene from the liquid per unit time.

METHODOLOGY

The conservation of mass is a fundamental concept of physics, which means the amount of mass remains constant--mass is neither created nor destroyed. If we change the state of material i.e., in this case a liquid to a vapor/gas phase, the overall mass remains the same but the volume that the fluid occupied changed and correspondingly the density must change also. Since mass remains the same, one can take the product of the density (or airborne concentration) and the volume to determine the mass. Therefore, the mass in the liquid form should equal the mass found in the vapor/gas phase.

This fundamental concept of physics was used in determining the benzene evaporation rate from a historic Liquid Wrench formulation. The Liquid Wrench formulation was allowed to evaporate under controlled conditions in an isolated chamber and air transport system. Air velocity, air temperature, liquid temperature, and humidity were controlled and/or monitored. Scientific principles and standard industrial hygiene and Environmental Protection Agency (EPA) methods, including industry accepted procedures and practices were used for the quantification of benzene in air and conversion to the equivalent benzene mass loss from the liquid medium.

Glove Box-Type Evaporation Chamber (GBTEC) and Air Transport System

The GBTEC was designed for air to flow laterally through the chamber at a controlled velocity. The inlet ducting measured two feet wide by two feet tall to match up with the GBTEC dimensions. The ducting was made from Dow Super-TUFF-R, a one inch thick polyisocyanurate foam core board with an aluminum foil backing on one side and a plastic backing on the other side. The duct was constructed so that the foil backing made up the interior of the duct. Downstream of the GBTEC, the duct tapered down to a 0.708 feet wide by 0.708 feet tall dimension. Just in front of the taper, a 24 inch square HVAC diffuser was inserted in the reverse direction to collect the air and force it into a 45 degree direction from the incoming air flow and which compressed it through a 12 inch round outlet into the taper. The smaller duct was connected to a 90 degree right turn. The diffuser, taper, and 90 degree turn were designed to promote mixing of the evaporation hydrocarbon solvent on obtain a homogeneity of the mixture in the air stream. The duct continued in a straight line after the 90 degree turn for approximately 14.4 feet.

The GBTEC was constructed of square tubular ¾" steel frame with Plexiglas sides and sheet steel bottom. The tubular steel was welded together and to the steel plate bottom. The Plexiglas was secured with screws to the tubular steel. Once constructed, the Plexiglas was sealed to the steel using silicone. The removable Plexiglas top section was sealed using soft pliable rubber gasket material. The top section was held in place with bungee cords to allow quick removal and access to the chamber. One side of the GBTEC was fitted with eight inch round ports to allow chemically resistant gloves to be inserted into the chamber.

Prior to initiation of the benzene evaporation rate study, testing of the chamber was conducted in order to determine sampling point locations, confirmation of adequate mixing, and to assure laminar flow throughout the system. Cyclohexane was used to generate a consistent evaporation rate of into the air and measurements were taken with the ChemSense 600 at nine locations in the duct area (the duct cross sectional area was divided up into nine equal sections) and compared these values to determine the standard deviation in values based upon sample location. This result indicated consistent mixing in the air stream. Therefore, the center of the duct was selected as the sampling point for the data collected in the Trial runs.

The GBTEC and duct system were designed to produce laminar flow in the duct work prior to and through the GBTEC so that the air flow could be quantified. A series of holes spaced three inches from the side of the duct and six inches apart were made so that testing of the flow characteristics could be made. Chemical smoke tubes were used to visually document the flow pattern through the GBTEC. The flow was near laminar throughout the GBTEC and met design expectations.

The sampling points for the ChemSense 600 (direct read instrument) and Summa canisters (air grab samples) were located approximately 9.6 feet downstream (approximately 13.5 duct diameters) from the 90 angle. Two viewing windows were inserted to allow positioning of the sampling tubes and for positioning of the thermo-

anemometer for conducting a secondary thermo-anemometer traverse for flow rate and conversion into volume per unit time. The GBTEC duct system was connected to the air moving device (Abatement Technologies HEPA-AIRE H1000V) and the exhaust from the air moving device was directed to the outside environment.

Sampling and Analytical Methodology

The ICx Analytical Instruments' ChemSense 600 direct sampling mass spectrometer was chosen for this evaluation and positioned to sample downstream from the evaporating benzene or Liquid Wrench mixture. The ChemSense mass spectrometer collected air from the sample stream directly into the vacuum system of the detector where the glow discharge source resides and creates ions inside the cylindrical ion trap mass analyzer (CIT). The ChemSense uses a CIT to separate ions according to their mass-to-charge ratios. Since there is no pre-concentration or distinct sampling event, the resulting data is continuous and, included some averaging, recorded at about 1 Hz.

Summa Canisters were used to obtain air samples of evaporated solvent vapor at the downstream location adjacent to the sampling port used for the direct reading ChemSense 600. A Summa canister is an airtight, stainless-steel container with an inner surface that has been electropolished and chemically deactivated. The advantage of the Summa canister is that the air being sampled is "drawn" into the canister by the high vacuum thereby eliminating the need for pumps or other powered equipment. Two (2) Summa canister samples were obtained for each Trial 1-3 for each day of sampling. The Summa canisters were analyzed in accordance with EPA Method TO-15 by an independent laboratory.

Background/baseline air samples were collected to determine the cleanliness of the air prior to the start and during each trial run. Prior to initiating a trial run, the room air was sampled for two minutes using the ChemSense 600 direct reading instrument. This was then followed by two minutes of air sampled inside the duct while the air moving device was on and set for a laminar flow rate of approximately 25 fpm.

Air samples were also collected at the entrance of the duct system during each trial run using a MSA Escort Elf low volume air sampling pumps drawing air at approximately 0.2 liters per minute through a coconut shell charcoal tube in accordance with NIOSH sampling and analytical method NIOSH 1501. Ambient air samples for determination of background benzene concentration were obtained throughout the duration of each of the 12 trials. These air samples were placed approximately 0.5 m from the upstream duct opening and were analyzed in accordance with NIOSH Method 1501 by an independent laboratory.

Residual oils remaining on the plate glass following the test run were collected and submitted to an independent laboratory for benzene analysis. A razor blade was used to remove any remaining oil from the plate glass and placed into 40 ml bottles with a gas tight silicone/Teflon cap. The sealed bottles were stored under refrigeration at -1.0 °C until shipped under blue ice packs to the independent laboratory.

The residual oil left on the plate glass after Run 3 was scraped into the bottle eight minutes after the completion of the run. The residual oil left on the plate glass after Run 4 was scraped into the bottle at 29 minutes after the completion of the run. The residual oil left on the plate glass after the run was completed on 15 June 2009 was scraped immediately after the completion of the run.

A VelociCheck thermo-anemometer made by TSI was used to conduct duct traverses at the entrance to the GBTEC to determine the laminar air flow speed and determine the volumetric flow rate based on the size of the duct. The velometer direct reading instrument measures linear air movement across a thermistor sensor detector.
Prior to each trial run, the TSI Q-Trak Model 8550 IAQ meter was set on sampling mode and used to data log the air temperature and humidity during each trial over the three day study. The Q-Trak utilizes a thermistor sensor detector to measure temperature with an accuracy of ±1°F, a resolution of 0.1°F and range of 32 to 122°F. Relative humidity was detected with a thin film capacitive sensor, which has an accuracy of ±3% RH, a resolution of 0.1% and range of 5 to 95%. A Kestrel 4200 barometric pressure meter was set on sampling mode and used to data log the barometric pressure during each trial. The Kestrel contains a monolithic silicon piezoresistive pressure sensor with second-order temperature correction. Accuracy is ±1.5 hPa/mb.

A Fluke 62 Mini IR Thermometer was used to measure the temperature of the glass and of the liquid during each trial immediately after dispensing the liquid and at one minute intervals until the completion of the test.

Surface area analysis of the liquid phase was conducted through the use of digital photographic imaging and area was calculated using ArchiCAD software. A template with a grid work of one square centimeter markings was placed beneath the glass surface. Following the pouring of the liquids, digital photographs were taken of the liquid pool at one-minute intervals until the downstream measurement of evaporated solvent was completed. The digital photographs were imported into the ArchiCAD program and the surface edge of the liquid was mapped throughout the evaporation period. Using the template as the calibration guide, the surface of the liquid was calculated in terms of square centimeters (cm^2). Manual adjustments were made on some mapping due to the clipping of a section of the liquid pool.

Historic Formula Recreation

The Liquid Wrench formulation that was manufactured in the 1960 through 1978 timeframe was selected for use in the benzene evaporation rate study. This product involved a mixture of hydrocarbons identified as "raffinate" and an oil additive. This raffinate material was a by-product of the coal process. According to historical records, this "raffinate" material contained various aliphatic and aromatic hydrocarbons in varying amounts, including benzene at concentrations of approximately 3%.

The "raffinate" product is no longer available from the coal process. A product manufactured from the oil production process at Sunoco that was determined by analysis to be similar in chemical composition to the original raffinate produced from the coal process back in the 1960s was secured. Three 125 milliliter (ml) containers of this material were obtained for the reformulation of the Liquid Wrench. A base oil was added to the "raffinate" in order to match the original product formulation.

The composition of the reformulated penetrating solvent was analyzed by GC-FID. Analysis was provided by an AIHA, EPA accredited laboratory. Table 1 below shows the concentrations of the individual compounds in the reformulated penetrating solvent compared to the constituents of the historic product formulation. Additionally, the physical properties of the reformulated product were evaluated for flash point, density, and initial boiling point. The American Society of Testing and Materials (ASTM) methods used to determine the physical properties along with the results are summarized in Table 2.

Table 1: Chemical Composition of Reformulated Penetrating Solvent and Original Product

Compound	Percent by weight (reformulated)	Avg. Wt. Pct. (original product)
Cyclohexane	17.7	20
m & p Xylenes	14.9	15
Methyl cyclohexane	10.9	12
Toluene	8.7	10
Ethyl benzene	8.4	8
Benzene	5.1	3
n-Hexane	4.0	-
o-Xylene	2.2	2
Pentane	1.5	-
Heptane	0.76	-
Other hydrocarbons	14.1	-

Table 2: Physical Properties of Reformulated Penetrating Solvent (RPS) and Original Product (OP)

Parameter	Units	Method	RPS Result	OP Result
Flash point	°F	ASTM D56	87	27
IBP (distillation)	°F	ASTM D86	158.0	170
Specific Gravity	60°/60°F	ASTM D1298	0.7883	0.820

Comparing the chemical and physical properties of the RPS and OP showed generally good agreement. Therefore, it can be concluded that data generated during the benzene evaporation rate study using the RPS is representative of how benzene would have evaporated from the OP.

RESULTS

Background/Baseline Air Samples Results

Prior to the start of each trial run, a room-air measurement followed by a duct-air measurement for benzene was conducted using the ChemSense 600. Benzene was not detected by the ChemSense 600 or on any of the charcoal tubes in the room-air at the air duct/chamber intake during any of the subsequent Trials conducted on Day 2 and Day 3. The results of laboratory analysis for ambient benzene sampling are summarized in Table 3.

Table 3: Results of Laboratory Analysis for Charcoal Tube Air Samples

Sample No.	Reported Mass (ug)	Reporting Limit (ug)	Volume (liters)	Concentration (ppm)
061109 CHAR-5	ND	1	11.7	<0.027
061109 CHAR-6	ND	1	10.6	<0.030
061109 CHAR-7	ND	1	10.4	<0.030
061109 CHAR-8	ND	1	5.7	<0.055
061209 CHAR-9	ND	1	11.6	<0.027
061209 CHAR-10	ND	1	10.6	<0.030
061209 CHAR-11	ND	1	7.7	<0.041
061209 CHAR-12	ND	1	7.3	<0.043

*ND = non-detected.

ChemSense 600 Results

A ChemSense 600 ion-trap mass spectrometer recorded the benzene mass concentration during each evaporation trial, which was subsequently converted to the cumulative mass of benzene evaporated per unit time. The half-life (time it takes for one-half of the all the mass of benzene to evaporate from the Liquid Wrench) point of the evaporation period was also calculated.

- For Day 2 (evaporation of 20 ml of reformulated product containing 5.1% w/w benzene from a plate glass) the average benzene evaporation time for Trials 1 through 3 was approximately 12 minutes with an average half-life point of less than three minutes.
- For Day 3 (evaporation of 20 ml of reformulated product containing 5.1% w/w benzene from simulated product use) the average evaporation time for Trials 1 through 3 was approximately 11 minutes with an average half-life point of less than three minutes. Table 4 contains a summary of the evaporation rate data for each trial.

Table 4: Time for Half and Time for All of the Initial Mass of Benzene to Evaporate

Trial Run	Half-life Time (min.)
Day 2, Trial 1 (20 ml LW on plate) ~ 27 fpm	3.05
Day 2, Trial 2 (20 ml LW on plate) ~ 27 fpm	2.76
Day 2, Trial 3 (20 ml LW on plate) ~ 27 fpm	2.67
Day 3, Trial 1 (20 ml LW on part) ~ 27 fpm	2.79
Day 3, Trial 2 (20 ml LW on part) ~ 27 fpm	3.46
Day 3, Trial 3 (20 ml LW on part) ~ 27 fpm	1.76
Day 1, Trial 4 (20 ml benzene) ~ 50 fpm	5.01
Day 2, Trial 4 (20 ml LW on plate) ~ 50 fpm	1.99
Day 3, Trial 4 (20 ml LW on gloves) ~ 27 fpm	1.94

Graphic representations of the cumulative mass evaporation and airborne concentration measured by the ChemSense 600 for each day are shown in Figures 1 through 4 below.

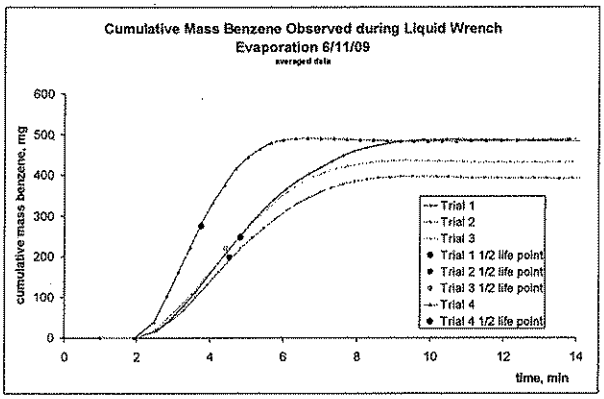

Figure 1

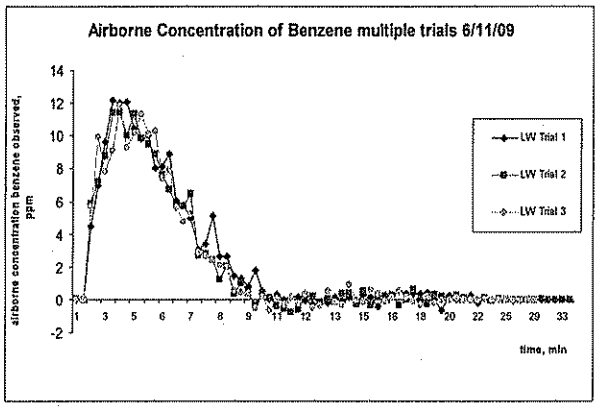

Figure 2

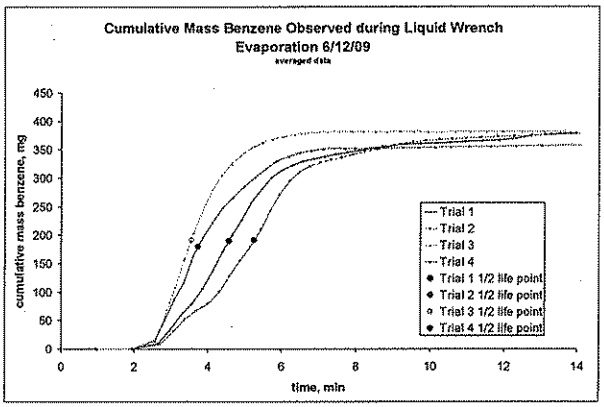

Figure 3

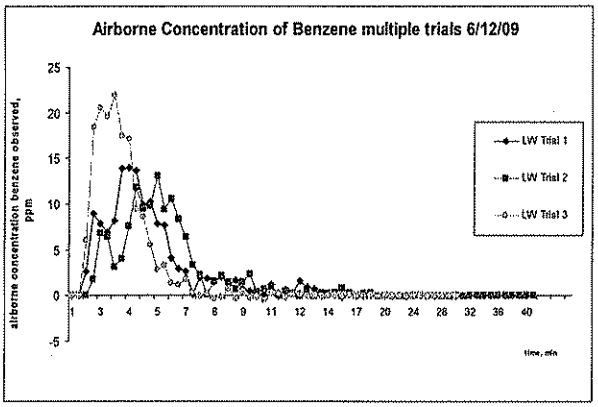

Figure 4

Figures 1 and 3 show the cumulative amount of mass evaporated from the Liquid Wrench at time = t in minutes. Figures 2 and 4 show the measured airborne concentration in parts per million (ppm) in the exhaust stream.

Summa Canister Results

Twelve Summa canisters were used to sample the downstream air for benzene that evaporated from the Liquid Wrench. The samples were taken at the same location as the ChemSense 600 for comparison of the data obtained by the ChemSense mass spectrometer. The laboratory reported that canister no.'s 11, and 12 were still under vacuum upon receipt for analysis, and accordingly were not analyzed. Tables 5 and 6 summarize the Summa canister results from days 2 and 3 of the study.

Table 5: Summa Canister Results for Day 2 – Liquid Wrench Evaporated from Plate Glass

Can No.	Δt (min)	Airborne Concentration in ppm
7	1	9.00
9	3	15.00
11	5	Not Analyzed
8	7	5.00
10	9	0.15
12	11	Not Analyzed

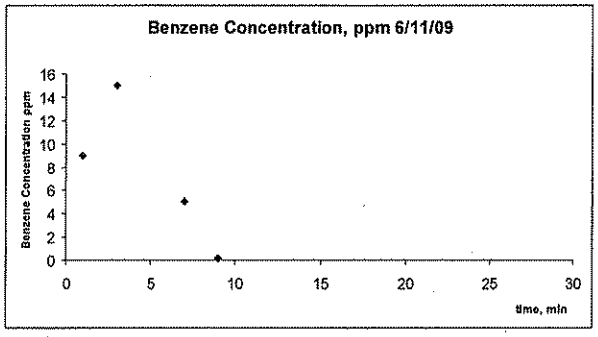

Figure 5

Table 6: Summa Canister Results for Day 3 – Liquid Wrench Evaporated from Parts

Can No.	Δt (min)	Airborne Concentration in ppm
13	1	11.00
15	3	3.00
17	5	0.62
14	7	1.90
16	9	0.58
18	11	0.04

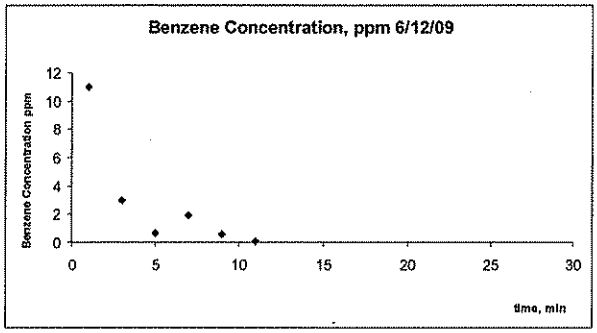

Figure 6

The Summa canister data were the result of very short term grab samples (i.e. 2-7 seconds). Based on the raw data from the ChemSense 600, the fluctuations in the concentration which, when averaged out over time, depict a trend lines as seen in Figures 2 and 4 above that are similar to the trend lines obtained from the Summa canister data, Figures 5 and 6. The Summa canister sample collected at minute 9 of Day 2, Trial 2 showed a concentration of 0.150 ppm. The Summa canister sample collected at minute 11 of Day 3, Trial 3 showed a concentration in the airstream of 0.04 ppm. This

demonstrates there are extremely low concentrations of benzene left in the Liquid Wrench residue after 9 and 11 minutes of exposure time to the air.

Air Flow Through GBTEC Results

The average velocity of air through the GBTEC for the three study days was approximately 27.09 fpm for the first three trials. Trial 4 on Day one and Day two were 48.88 fpm and 51.94 fpm respectively. Trial four on Day three was 27 fpm. Table 7 contains a summary of the average velometer results.

Table 7: Average of Measured Air Velocity in fpm for Each Trial of Study Days 1-3

	Day 1	Day 2	Day 3	mean
Trial 1	27.63	28.88	26.44	27.65
Trial 2	26.06	25.07	28.69	26.61
Trial 3	27.50	26.34	27.22	27.02
mean	27.06	26.76	27.45	27.09
Trial 4	48.88	51.94	27.00	

Temperature, Relative Humidity, and Barometric Pressure Results

Over the three days of testing, the average room temperature was 25.5° C and ranged from a low of 24.2° C to a high of 26.2° C. The average temperature of the glass plate inside of the evaporation chamber was 25.4° C and ranged from a low of 23.8° C to a high of 26.4° C. The plate glass temperature tracked closely with the air temperature.

The average relative humidity was 45.7% and ranged from 42.4% to 49.5% over the three day study.

The barometric pressure ranged from 1007.8 millibar (756 mm Hg) to a high of 1013.5 millibar (760.2 mm Hg) over the three days study.

Residual Oil Analysis

Upon completion of the Liquid Wrench trial runs on Day 2 the remaining oil was scraped off the removed from the plate glass using a razor blade and placed into a 40 ml bottle with a gas tight silicone/Teflon cap. The sealed bottles were stored under refrigeration at -1.0 °C until shipped under blue ice packs to an independent laboratory.

The residual oil left on the plate glass after Run 3 was scraped into the bottle eight minutes after the completion of the run. The residual oil left on the plate glass after Run 4 was scraped into the bottle at 29 minutes after the completion of the run. The residual oil left on the plate glass after the run was completed on 15 June 2009 was scraped immediately following the completion of the run.

Approximately 2 ml of residue was captured for each run above and sent to the laboratory for analysis of benzene content in the oil. As noted in Table 8, all results were below the limit of analytical detection.

Table 8: Residual Oil (RPO)From Plate Glass Analyzed for Benzene Content

Oil Sample Number	Results in ppm and percent by weight
RES-oil-1 (Day 2, Trial 3)	< 25 ppm or < 0.0025%
RES-oil-2 (Day 2, Trial 4	< 35 ppm or < 0.0035%
RES-oil-3 (Trial 6/15/2009)	< 27 ppm or < 0.0027%

DISCUSSION

ChemSense 600 Confounders and Interferences

Since the direct inlet mass spectrometric technique on the ChemSense 600 uses no chromatographic separation, all of the chemical compounds present in a mixture are ionized and detected simultaneously. The National Institute of Science and Technology (NIST) standard reference mass spectra for the compounds anticipated to be detected in the gas phase during the evaporation of Liquid Wrench show that there is a slight contribution to the benzene signal from the ethyl benzene and mixed xylenes. When these compounds are ionized, approximately 10% (according to NIST) of the ions produced show up as a benzene signal.

To correct for this interference, a mixture of ethyl benzene and m-xylene was evaporated in the evaporation chamber, and the resulting data allowed for an experimental determination of the fraction of the ethyl benzene and xylene molecules that contributed to the benzene signal. The experimental determination resulted in a ratio that was nearly constant over the entire evaporation episode at 10.38%. The intensity of the signal for the ethyl benzene and xylenes was multiplied by 0.1038, and the result was subtracted from the intensity of the signal for the benzene at the time the ethyl benzene and xylene signals occurred.

During the evaporation of Liquid Wrench, which contained approximately 5% benzene by weight, it was noted that only about one half of the benzene evaporated was observed at the mass spectrometer, based on mass balance calculations that multiplied observed concentrations by measured volumetric flow rate through the evaporation apparatus. The evaporation of pure benzene gave very good mass balance values, so it was hypothesized that one or more compounds in the mixture was suppressing the signal attributed to benzene in the mass spectrometer. Several mixtures of benzene and cyclohexane were evaporated, and the resulting data was used to perform mass balance equations to ascertain if a relationship between the fraction of benzene in a mixture and the fraction of the total mass observed at the mass spectrometer could be obtained. Such a relationship was found to exist and for mixtures with a low concentration of benzene to cyclohexane, signal suppression is occurring. The exact mechanism of this signal suppression was not

determined, but it should be noted that there is absolutely no evidence to suggest this signal suppression, or "loss of benzene" is anything other than reduced sensitivity of the mass spectrometer for benzene in the presence of the other organic compounds. During the cyclohexane/benzene mixture data collection, all liquid evaporated within the evaporation apparatus, suggesting that all the benzene made it into the vapor phase. However, the concentration of benzene measured vapor phase was suppressed due to the ratio of greater than three (3) to one (1) cyclohexane to benzene in the liquid mixture. The "missing mass," then, is the result of the mass spectrometer, not the result of some physical or chemical process that destroys benzene or keeps it from evaporating.

CONCLUSIONS

The evaporation of the 20 ml of complex mixed benzene-containing hydrocarbon product (5% wt/wt benzene) at standard temperature and pressure (STP) and with an average airflow rate of 27 fpm at the air-surface interface demonstrated an evaporation half-life on average of less than three minutes.

This study demonstrated a plausible process using mass transfer for determining evaporation rates of single volatile constituent in a complex solvent/product mixture.

John W. Spencer, CIH, CSP
Environmental Profiles, Inc.

9 July 2009
Date

Support Documents Follow:

Support Document 1:	Historic "Raffinate" Formula
Support Document 2:	Bureau Veritas Laboratory Results of Sunoco Raffinate GC-MS
Support Document 3:	Bureau Veritas Laboratory Results for Preliminary Liquid Wrench Reformulation GC-MS
Support Document 4:	Bureau Veritas Laboratory Results for Preliminary Liquid Wrench Reformulation GC-FID
Support Document 5:	Bureau Veritas Laboratory Results for Final Liquid Wrench Reformulation GC-FID
Support Document 6:	Historic Liquid Wrench Formulation
Support Document 7:	James Wells deposition excerpts, Historic Liquid Wrench Oil Additive Document
Support Document 8:	Crystal 100 Base Oil Specifications Sheet
Support Document 9:	Penniman & Browne Laboratory Analysis for Physical Properties of Reformulated Liquid Wrench
Support Document 10:	Dr. Adam Keil's Benzene Evaporation Study, Direct Sampling Mass Spectrometer Method Development and Data Collection Summary
Support Document 11:	Surface Area Data of Benzene Poured on Plate Glass
Support Document 12:	Surface Area Data of Reformulated Liquid Wrench Poured on Plate Glass
Support Document 13:	Chart Depicting Signal Suppression of ChemSense 600 in Mixtures of Cyclohexane and Benzene
Support Document 14:	Field Notes
Support Document 15:	EMSL Plate Glass Residual Oil Analysis
Support Document 16:	MSDSs for Chemicals Used in the Reformulation of Liquid Wrench
Support Document 17:	Study Protocol

APPENDIX V:

Comparison of the values Mr. Petty's equation yielded values experimentally derived values

Source / Value	Susten	Adami	Adami	Adami	B & McA	B & McA	B & McA	F-B	Hanke
% Benzene in Mixture	0.5	0.39	0.74	1.06	5	5	5	100	100
Reported Flux Value	0.011	0.0018	0.00271	0.00147	0.041	0.062	0.105	0.19	0.4
Est. Flux[1]	0.012	0.010	0.015	0.019	.052	.052	.052	0.354	.354
% Error[2]	9.1	455.56	453.5	1192.5	26.8	16.1	50.5	86.3	11.5

[1] Flux = 0.183 (% benzene conc) $^{0.6435}$

[2] Percent error = $\left| \frac{\text{value} - \text{value}_{\text{approximate}}}{|\text{value}|} \right|$

APPENDIX VI:

Summary of EPI spreadsheets used to calculate Mr. Knapper's estimated cumulative inhalation exposure

	Summary of Cumulative Inhalation Exposure to Benzene From Use of Liquid Wrench	ppm-years
Sheet 1	Repair of Lawn Mowers	0.03
Sheet 2	Work on Motorcycles	0.01
Sheet 3	New York Home - Restore Lincoln Car	0.00
Sheet 4	New York - Plumber's Helper (Summer)	0.01
Sheet 5	New York - Plumber's Helper (School)	0.02
Sheet 6	New York - Citgo Service Station	0.05
Sheet 7	Florida - Jackson's Garage	0.03
Sheet 8	Plumber's Helper/Plumber 1968-1975	0.50
Sheet 9	New York - Plumber	0.03
Sheet 10	Texas - Plumber	0.13
Sheet 11	Rebuilding Cars in New York and Texas	0.02
	Cumulative Inhalation Dose	0.83

APPENDIX VII:

Summary of EPI spreadsheets used to calculate Mr. Knapper's estimated cumulative dermal exposure to Liquid Wrench.

	Summary of Cumulative Dermal Dose from Use of Liquid Wrench	ppm-years
Sheet 1	Repair of Lawn Mowers	0.21
Sheet 2	Work on Motorcycles	0.10
Sheet 3	New York Home - Restore Lincoln Car	0.01
Sheet 4	New York - Plumbers Helper (Summer)	0.38
Sheet 5	New York - Plumbers Helper (School Year)	0.63
Sheet 6	New York - Citgo Service Station	0.09
Sheet 7	Florida - Jackson's Garage	0.06
Sheet 8	Plumber's Helper/Plumber 1968-1975	0.92
Sheet 9	New York - Plumber	0.06
Sheet 10	Texas - Plumber	0.24
Sheet 11	Rebuilding Cars in New York and Texas	0.04
	Cumulative Dermal Dose	2.72

APPENDIX VIII:

Summary of EPI spreadsheets used to calculate Mr. Knapper's estimated cumulative dermal exposure to Safety-Kleen solvents.

	Summary of Cumulative Dermal Dose from use of Safety-Kleen solvent	ppm-years
Sheet 1	Colintonio Home Safety Kleen parts washer	0.02
Sheet 2	Citgo Service Station	0.14
Sheet 3	Jackson's Garage	0.13
Sheet 4	Smithtown High School	0.13
	Cumulative Dermal Dose	0.41